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CREAMERY INSPECTION DATA

H. W. REDFIELD AND W. A. STOCKING

Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.

During the summers of 1918 and 1919, the authors jointly or separately visited approximately 150 creameries situated in the following states: Alabama, Arizona, California, Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New York, North Carolina, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, and Wyoming. Of these creameries, each of 70 manufactured 500,000 or more pounds of butter per year. Eighty of them manufactured respectively less than 500,000 pounds of butter per year. The total output of the entire group of creameries as reported by their managers was approximately 200,000,000 pounds of butter.

In each plant visited, the information recorded was combined from the word of the managers, from the records of the creamery, and from direct observation. The information sought included the total amount of cream received, and the percentages of this total obtained from shipping stations, from single shippers, by cream routes, and by delivery by the patron directly. Where cream was shipped, the range of distance covered by such shipments was approximated. Concerning the stock itself, the range of fat content, acidity, and basis of grading, if any, were recorded. With reference to methods of manufacture, the use and type of neutralizer, if any, and the methods of application were observed. The method, temperature, and time of pasteurization were recorded. The character and percentage of starter used were noted. Details of churning, when obtainable, were described. Concerning the resulting product, the factory grading, the percentage represented in each grade and the amount of salt used were tabulated, and finally the score of the different grades of butter manufactured and the methods of marketing were discussed with the management of each creamery.

Although the number of creameries visited is not great, care was taken to make the inspection cover as representative a series as possible. It is believed that a summary of the observations made in the course of this investigation may be of considerable interest. A very large number of investigators have discussed the problem of butter manufacture. No attempt will be made to review this extensive literature. For such discussions, the reader is referred to standard dairy references and the college and experiment station literature. Such investigations cover specific methods of manufacture, the applications of pasteurization to the production of a butter which will maintain its character in storage, the cause and nature of particular defects in the product.

In this investigation, which is the first of a series of studies upon the problem of butter, the authors endeavored to obtain enough observations upon the practical problems of production of cream, under the most varied conditions, of method of delivery, of the condition of the cream when received, of the methods of manufacture in the creamery, to aid in interpreting a series of intensive studies to be made by ourselves and others of experimental work in the creamery. This paper will be limited to a summary of the observations made in the field inspection of the creameries themselves.

SANITARY CONDITION OF PLANTS

The sanitary condition of the creameries was very satisfactory. This is true of the plants of all sizes, from the very smallest up to the very largest centralizing establishments. There were a few exceptions to this condition but such exceptions are to be anticipated among manufacturing establishments. The principles of sanitation as applied to creameries are so well worked out and so well known that failures of this kind are local and personal matters which should be looked after by boards of health.

EQUIPMENT OF PLANTS

On the whole the plants were efficiently equipped. In many, especially small ones, the equipment was not expensive, but in

practically every case the machinery was sufficient for doing satisfactory work and was of modern construction. Occasionally the equipment was somewhat out of date and badly worn. In some, especially of the larger plants, the equipment was of the most modern type and occasionally quite expensive.

It is noteworthy that the equipment in both large and small plants with few exceptions includes pasteurizing machinery of such type as to obtain satisfactory results. There are, of course, a series of small creameries, in particular sections of the country, in which pasteurization apparatus is inadequate or not present at all. It is clear, however, that the cost of adequate pasteurizing machinery does not interfere with its introduction in any successfully managed plant.

As a rule little criticism can be made from the standpoint of equipment. It is thus clear that dairy machinery as installed in the ordinary creamery is of such character as to admit of successful operation.

METHODS OF MANUFACTURE

The methods of butter manufacture observed throughout the territory visited are surprisingly uniform. It is evident, that the butter industry has become so well standardized that there is little difference in the essentials of manufacture in various parts of the country. Minor differences in detail of procedure in different sections of the country do occur. In individual plants in any locality such differences are occasionally found but these are, as a rule, unimportant in character.

So far then as the plants visited are representative of the butter industry, creamery butter is rapidly coming to mean butter made from pasteurized cream. Both large and small plants are using such apparatus successfully. Both flash and holding methods are in common use. The holding method seems to be more common in the smaller plant where the volume of cream handled is not very large. The temperatures and time of exposure vary in different plants. In holding pasteurization 145° F. for twenty to thirty minutes is most common. Occasionally

165°F. for ten or twenty minutes is used. Where the flash method was used, the temperature was varied from 165°F. to 185°F. In the larger plants there is the decided tendency to use the double flash method, in which the cream is heated to a moderate temperature as it passes through the first machine, and then goes directly to the second one where the desired temperature is obtained. In those large plants in which a grading of cream is practiced, there is a distinct tendency to pasteurize first grade cream at a considerably lower temperature than second grade cream. Such temperatures as 185°F., especially when accompanied by the use of a retarder, are closely associated with conditions in which poor cream or second grade cream becomes a prominent characteristic of the raw material.

There appears to be a decided tendency to discontinue the use of cream starters in all parts of the country. Two chief reasons were given for the discontinuance of this practice. In some places it is difficult to secure satisfactory material for making starters but the chief reason given is that the experience of recent years has proved that butter made from cream with low acidity keeps in storage better than that made from cream of high acidity. For this reason, primarily, most of the butter manufacturers are churning cream with as low acidity as possible. This, of course, eliminates the use of the starter. In those plants where the cream supply is received sour, the practice of reducing the acidity with alkalies is generally followed. The amount of alkali used depends upon the degree of acidity of the cream supply. In some sections of the country reduction of acidity is accomplished by the use of lime or lime water. In some sections soda is used. Some use milk of magnesia. In many plants a combination of two of these agents is employed. Occasionally cleansing powder was found in use. In most plants, especially of the larger ones, the percentages of moisture and salt in the finished product are very carefully watched and controlled, so that the finished product is a very uniform one from day to day in a given plant and also in different plants of an organization. The large volume of unsalted butter reported by these creameries is also noteworthy.

AGE OF CREAM

In respect to age of cream, there are marked differences in the different sections of the country. In those sections where sweet cream is delivered to the creamery, it is usually not more than one or two days old. In the sections where the creameries receive sour cream, it is practically always older. Probably a very large percentage of it during the summer time is from four to six days old upon arrival at the creamery. A small proportion is older, occasionally as much as seven or eight days of age when received. Sometimes shipments older than this are accepted. There is a tendency on the part of plant operators to urge the farmers to deliver as frequently as possible. It was not, however, the practice of the creameries or cream buying stations to refuse simply because of its age in days.

QUALITY OF CREAM

Sweet cream. In general the sweet cream was of good quality. In some cases, especially in the South, milk and cream at certain seasons became badly tainted from certain types of vegetation in the pastures. Feedy flavors were also reported in various parts of northern Michigan. Aside from the instances in which the feed was regarded as responsible, the sweet cream was usually satisfactory. In certain localities, notably northern Iowa, the smaller creameries in Arizona, and certain sections of California, sweet cream alone is received. Most of these plants receive their supplies from a relatively small area per plant. The exceptions to this are sufficiently noteworthy, however, to indicate that the number of these plants could be very greatly increased with resulting economy of operation and improvement of the butter supply as a whole.

Sour cream. The acidity of the cream varied considerably in the plants visited. Occasionally, cream was found only mildly acid, 0.2 to 0.3 per cent. In other sections, the acidity ran much higher. Extreme cases were found where the acidity tested 1.5 per cent. A rough average for sour cream might be 0.5 per cent. It is noteworthy that some of the sourest cream was

observed in the central states. The regions tributary to St. Louis, Kansas City, Omaha, Lincoln, Oklahoma City and Denver, showed a larger percentage of exceedingly sour cream than areas in the far South where temperatures are much higher. Neither climatic conditions nor the state of farming is sufficient to account for so much sour cream in some of these areas. In the South, notably Mississippi, where dairying has developed rapidly during the last few years, special attention has been given to the care of cream so that it reaches the plant with lower acidity than in many regions in which more might be expected because of more favorable climate. In Arizona where the climate is extremely hot but where the development of the butter industry has also been recent, cream was found delivered at the plant one or two days old but relatively low in acid. The same was equally true in the San Joaquin Valley of California, where the cream supply comes from comparatively short distances.

Much sour cream has a clean, sour flavor. Some part of it constantly shows various types of "off flavors." These are designated by the butter makers by such names as yeasty, vinegary, cheesy, stale, bitter, onion, weedy, metallic. There is some difference of opinion as to which of these defects cause the most difficulty. Stale and yeasty creams were, however, most generally condemned as making most serious trouble from the standpoint of the score of the butter obtainable after manipulation. Some butter makers regarded metallic cream as most troublesome and in a very few cases weedy flavors were reported as the most serious difficulty. Since weedy flavors are only a local matter, the stale and yeasty cream may be regarded as that which interferes most widely with the score of the finished product.

METHODS OF CREAM DELIVERY

Aside from the local product delivered by the farmer, three general methods of cream delivery were observed in various parts of the country: A, direct shippers; B, receiving stations; C, cream routes.

Of these three, the first two methods of delivery were first developed in those sections where dairying was somewhat scattered and the local supplies too small for successful manufacturing. Both are now large factors in many dairy communities. Some companies adhere rigidly to the direct shipper system while others use both the direct shipper and the receiving station methods. In most cases the butter maker stated that the cream received from the direct shippers is normally of better quality than that coming from the shipping stations. The reason given was that the direct shipper is in closer touch with the central company and can be informed directly when his product is unsatisfactory. In such cases it becomes easily possible to discriminate in price in favor of the better grades of cream. When cream is received from shipping stations, the person in charge of the station may have little knowledge of the dairy business. Cream is tested for fat and paid for at the time of delivery, and consigned to the creamery by its own agent. The cream from different shippers is generally mixed before shipping to the central plant, so that the cream of the individual farmer has lost its identity. Further, the men in charge of receiving stations are frequently poor judges of quality and in many cases they receive their commission on the basis of the amount of butterfat purchased irrespective of the flavor of the cream. All of these factors work together to depreciate the value of shipping station cream. These stations, as far as observed, were properly equipped for making the Babcock test, were generally insufficiently equipped for washing and steaming cans, and not equipped at all for cooling the cream.

These observations are in harmony with the statements of others with reference to shipping stations. In certain sections the delivery by cream routes was observed. Where automobiles are used, these routes extend as far as 30 to 40 miles from the central plant. The truck is usually owned and operated by the creamery. Sometimes the cream is gathered daily. In other cases the collections are made on alternate days. This system appears to be quite satisfactory where roads permit the constant operation of delivery trucks.

GRADING CREAM

In a constantly increasing number of cases cream is purchased by grade and a differential of 2 to 5 cents per pound of butter fat is paid the producer of good quality product. In many cases, on the other hand, especially at shipping stations, one price is paid for all cream regardless of condition. A general desire has been expressed by creamery operators to follow some grading system and to pay on the basis of quality. Thus far grading has failed in many sections, because of competition between creameries for the cream. This appears to be especially true where several creameries have shipping stations in the same territory with managers paid for quantity not quality of shipments.

In the plants receiving sweet cream, one grade of butter only is made, since the cream accepted is all sufficiently good in quality to produce a high grade product. In the sour cream plants they usually sort the cream into two or three grades when received. The first grade includes all cream which the butter makers consider sufficiently good to go into their first-grade product, for which they have established a market. Throughout much of the territory visited, this product scores about 90 to 91. The No. 2 grade includes cream which is more stale, foamy, or yeasty, or has other off flavors which are too pronounced to allow inclusion in the so-called first-grade product. The practice of various creameries differs, but this grade commonly is made to include such cream as will make a butter scoring from 88 to 90 according to the factory.

Number 3 grade includes the most pronounced stale, yeasty, cheesy, weedy, or other off flavors. In many of the plants, no cream was reported as too poor for use. In others an occasional can was returned to the farmer or made into packing stock. The percentage of cream going into the different grades in the various creameries differs markedly. In some cases all but about two per cent went into first grade. In others as high as 30 per cent would be in second grade and 5 to 10 per cent in third grade. Most plants limit the grading to first and second, except perhaps during the two or three hottest months of the year.

The disagreement in grading practice observed probably accounts for great differences observed in creamery butter, since the amount of "off flavored" cream put into first grade at the factory depends upon the judgment of the butter maker or the instructions which he has received. With a standardized output at a particular market score, first grade is made to include all off-flavored cream which can enter without depressing the score of the butter below this particular point.

The importance of the introduction of this off-grade cream into first grades can hardly be overestimated. Observations in certain of these creameries have shown that sour cream in otherwise proper condition can be made into really high-grade butter, but the introduction of comparatively small percentages of off-flavored stock into so-called first grade lowers materially the general level of the product. When this product, as from the group of large plants in the Great Plains and Prairie regions, totals to hundreds of millions of pounds, that lowering of the general level has a very wide effect upon the industry as a whole.

While in theory, all parties recognize the desirability of grading, adequate steps toward the establishment of recognized grades have only recently been taken. With the approval of some dairy organizations, the dairy commissioner of Kansas and later the commissioners of Nebraska, Missouri, Oklahoma, and Colorado have promulgated a grading system. In their announcements the creamery is advised to include in first-grade product only cream which is medium or slightly sour but with a clean, acid taste, and sweet cream. All cream which is recognizably metallic, weedy, oily, cheesy, greasy, bitter, tainted, contains colostrum, is yeasty, stale or musty or very sour definitely goes into second or third grade according to the intensity of the off flavor. The terms used are those well known and in common use in the creamery industry and the desirability of such grading is quite generally recognized. The observations made indicate clearly that a comparatively small percentage of the total cream would be designated by any one or any combination of these particular off flavors. It is, therefore, clear that the low general level of the output of large numbers of

factories is fairly definitely due to the inclusion of materials in first grade which belong properly in second-grade butter or which should not be used at all for creamery butter.

The regions visited show a marked tendency toward a higher grade of butter in those plants in which a sweet cream is used. This applies to large plants as well as small plants. Butter from such plants normally scores from 2 to 4 points higher than that in those plants using sour cream. While these higher grades of butter were more commonly found in small plants drawing their supply from local territory, the occasional exception is noteworthy. Certain large plants, in which the collection of carefully produced cream is organized along proper lines, produce an equally high grade of product. Further, in many small plants the methods of operation are not as uniform and the product when finished is more variable than in the larger plants.

Under such conditions, small creameries produce some of the lowest grades of butter. The smaller plant with its smaller output is also at a disadvantage in shipping and selling its product. As a result butter of varying grade in small lots frequently commands a less satisfactory market than butter of very moderate quality but uniform from day to day and in large quantity. This disadvantage can only be offset by disposal of the product to local markets or by such grouping of plants as will give greater advantage in selling.

DISCUSSION AND SUMMARY OF OBSERVATIONS

1. The flavors which were especially criticised by the creamery men themselves as preventing the manufacture of better butter, named in the order of their importance, were yeasty, stale, bitter, metallic, unclean, weedy, cheesy, and vinegary cream.

2. Off-flavored cream was found in all sections visited, predominantly in such sections as permitted the delivery of cream from 4 to 6 days old. The causes of such flavors were not observed in this investigation, although dirty utensils have been many times reported by others.

3. Poor quality in butter is primarily due to poor quality in cream. This is almost invariably associated with failure to

grade properly. It is also associated with failure to pasteurize in a few of the factories.

4. Sour cream even with acidity up to 0.7 per cent, if free from taint, can be made into butter scoring 92 to 93, by the newer and better organized factories. Scores higher than this are reached regularly from cream of really high quality.

5. The factors leading toward improvement in quality in butter, as observed, were (1) Location of the factory as closely as possible to the supply of cream; (2) The collection of cream every day by means of cream routes or by direct delivery; and (3) Cooling the cream at all times before manufacture.

6. The quality of cream and the quality of butter made from it is not primarily dependent upon the size of the plant or the radius of its cream-producing territory but upon the intelligent care used in its production, upon the regularity and promptness of its delivery, and upon its proper grading and manufacture at the factory.

THE POSSIBILITY OF INCREASING MILK AND BUTTERFAT PRODUCTION BY THE ADMINISTRATION OF DRUGS. II

ANDREW C. McCANDLISH AND T. M. OLSON

Dairy Husbandry Section, Iowa State College, Ames, Iowa.

The process of milk secretion is not yet fully understood and there is extreme difficulty in determining some of the factors which influence it. It is the belief of many that certain drugs have galactagogic powers and will increase not only the total yield of milk and butterfat but also the percentage of fat in milk. Work with laboratory animals has apparently demonstrated the galactapoietic powers of a few drugs and similar results are also reported in certain cases with the human subject. The use of galactagogues in commercial dairying would be out of the question but the study of the possibilities of their use with cows on official or semi-official test is of interest. Attempts have been made by men in charge of herds to use such materials with the special object of increasing the percentage of fat in milk and the purpose of the work reported here is to ascertain, if possible, the probable results of such attempts.

No attention will be given here to experimentation with mammals other than the cow, for the simple reason that though much valuable work has been done with these subjects the results need not necessarily be directly applicable to the cow as there may be certain generic differences in physiological activity. It is known that in some cases, especially with the human subject, variations in milk production can be brought about much more readily than in the case of the cow.

The possible ways by which drugs may influence the mammary gland are many and varied, and in order to better understand the action of any specific drug it is well to consider at least some of these possibilities:

1. The action of the drug may be directly on the protoplasm of the secretory cells, either stimulating or inhibiting the action of the cells.

2. The secretory nerve terminations in the mammary gland may be stimulated or depressed, thus resulting in either an increased or decreased secretion of milk.

3. The action of the heart may be influenced and produce an increase or decrease in the rate of circulation of the blood, thus altering the volume of blood and the amount of nutrients which would pass through the udder.

4. The general vasomotor influence of drugs, in increasing or decreasing the amount of blood passing through the udder, by a vasoconstriction of arterioles in other parts of the body or by dilatation of the arterioles in the mammary gland, is important.

5. The effects of drugs on the digestive system, through their influence on the activity of digestion and absorption, and ultimately the amount of nutrients available for milk and fat production, are worthy of consideration.

6. The action of drugs on organs indirectly associated with the mammary gland might influence milk and fat production.

As these actions may be brought about separately or in almost any combination and in varying degrees of intensity, it is seen that the problem of the influence of drugs on milk secretion is a complicated one and the fact that individual cows vary in degree of susceptibility to drug action increases the complexity.

The problem is here treated with the view of determining the possibility of influencing the production of healthy cows and more particularly the percentage of fat in the milk. In conducting this work the one or two day tests of the dairy cattle breed associations were kept in mind because it is only in such tests that there would be the greatest opportunity and temptation to use drugs, and it is also fairly well recognized that a slight increase in the percentage of fat in the milk might be maintained for a few days only by the use of drugs, and in addition continued drug administration would be more readily detected.

There is a long list of substances popularly reputed to have galactagogic effects—amongst these are the aromatics, fennel, anise, caraway, juniper berries, coriander, dill, pimpinella, calamus; the bitter stomachics, sulphur, the neutral salts, the antimony preparations, and many others—but distinction must

be made between the use of drugs based on a knowledge of their physiological action and the use of those indicated by empirical teachings. The popular milk powders are compounded largely from the constituents just stated.

RÉSUMÉ OF PREVIOUS WORK

Very little experimental data is available on the influence of drugs on the milk and fat production of dairy cows, and only those used in the work reported will be considered here.

Aloes. It was found by Lanzoni (3) that the fat percentage in cow's milk was decreased by the administration of aloes, while McCandlish (4) found that aloes decreased milk production 1 per cent and increased the percentage of fat 4 per cent and the total fat yield 3 per cent. Henderson (2) found a decrease in both milk and fat yield and an increased percentage of fat.

Castor oil. According to McCandlish (4) castor oil caused a decrease of 10 per cent in fat percentage and 11 per cent in the total fat yield.

Strychnine. It was reported by McCandlish (4) that a mixture containing nux vomica decreased the milk and fat yield but increased the fat percentage only slightly, though with one cow in two trials there was an appreciable increase in the percentage of fat accompanied by a marked decrease in milk yield. Henderson (2) obtained negative results with nux vomica.

Sodium cacodylate. No reports are available on the use of sodium cacodylate but Hays and Thomas (1) obtained negative results on using Fowler's solution of arsenic.

Results are obtainable from the references given on a few other drugs but they are not included here as the other drugs mentioned were not used in this work.

PHYSIOLOGICAL ACTION OF THE DRUGS USED

In this work the drugs used include castor oil, aloes, strychnine, sodium cacodylate, rhubarb, potassium iodide, urotropin and benzoic acid. These have been chosen in view of the fact that a knowledge of their physiological action would seem to

indicate some possibility of their either directly or indirectly influencing the mammary gland.

Castor oil. This is a bland, non-irritating fluid, and in itself is not a purgative. On passing into the intestine, however, it is saponified by the pancreatic juice, and the ricineolates formed from the ricineoleic acid liberated are irritant and cause purgation. In this way nutrients that might otherwise be utilized are carried off and a general depression is also produced.

Aloes. The action of aloes begins in the large intestine, a fact which accounts for its slow action, and its active stimulation of peristalsis in this part of the alimentary tract. The active principle of aloes, aloin, is responsible for the purging action. It is also very bitter and therefore excites the salivary and gastric but not the intestinal secretions. The end products of aloes absorbed from the large intestine are eliminated by the bowels, kidneys and mammary gland. Its elimination by the latter route may cause a looseness of the bowels of the suckling animal, if a sufficient amount of aloes has been given to the dam. It sometimes causes diuresis; induces reflex irritation of the female pelvic organs; is an emmenagogue and may be abortifacient.

Rhubarb. This is a stomachic and bitter tonic, and therefore increases the salivary and gastric secretions, improves digestion, stimulates the appetite, and the vascularity and movements of the stomach. Its activity is partially due to its solvent action on bile. Rhubarb contains a considerable amount of tannic acid, which acts as an astringent and, after the evacuation of the bowel, may cause constipation. The presence of chrysophanic acid in rhubarb sometimes gives a yellow tinge to the skin, urine, sweat, and milk.

Potassium iodide. This is an alterative and therefore exercises an influence upon the nutritional and metabolic processes of the body. It is absorbed and eliminated rapidly, escaping from the body in all excretions and secretions, but largely through the kidneys and salivary glands. Although the greater portion escapes within twenty-four hours after administration, some remains in the body, resulting in an accumulation, following the administration of successive large doses.

Strychnine. When strychnine is given in therapeutic doses, a stimulating action on the central nervous system, especially the spinal cord, is found. The sense of touch becomes more delicate, and excitability more marked. Larger doses cause twitching of the muscles, followed by tremors, and then convulsions, in which all the muscles of the body are involved. The proper functioning of the respiratory muscles are interfered with, resulting in deoxygenated blood. The heart action is slowed by the stimulation of the cardio-inhibitory center, and the vaso-motor center is stimulated, causing a constriction of the splanchnic vessels, deflecting the blood from the internal organs to the skin and limbs. A complete disorganization of the vaso-motor center follows an overdose. Strychnine increases the flow of saliva, stimulates the appetite, and increases the activities of digestion. It is absorbed mainly from the intestine.

Sodium cacodylate. This is less toxic than other arsenic compounds, due to the slow liberation of arsenious acid in the animal body. It is alterative, modifying nutrition. It stimulates the central nervous system, and induces vaso-dilatation of the capillaries. Sodium cacodylate is eliminated in the urine, feces, sweat, and milk.

Urotropin and benzoic acid. No direct action can be attributed to urotropin, but it liberates formaldehyde, which acts as an irritant and a disfectant. The liberation of formaldehyde is accelerated by the use of an acid. It is eliminated largely through the kidneys, although small quantities can be detected in other excretions and secretions of the body.

METHODS OF EXPERIMENTATION

The four cows used in this experiment were allowed to remain with the general herd and were milked twice each day by the same milker; a sample was taken from each milking for the determination of butterfat by the Babcock method.

Information concerning the animals used has been tabulated and where necessary it is calculated to November 16, 1919, the day on which the trial started.

The feeding of the cows was conducted along with that for the general herd and records of the feed consumed were obtained. The animals were watered twice daily in the barn during bad weather but otherwise outdoors when they were exercising.

The experiment may be divided into two large sections, as it was believed best in the middle of the work to rest the cows for ten days and alter their grain rations to some extent.

TABLE 1

Animals used

	cow 298	cow 323	cow 373	cow 398
Breed	Grade Guernsey	Grade Holstein	Grade Holstein	Grade Jersey
Age, years	4	3½	2½	2
Fresh, days	112	75	15	51
Previous lactations	2	1	0	0
Live weight, pounds	860	980	970	700

TABLE 2

Daily rations

	cow 298		cow 323		cow 373		cow 398	
	First section	Second section	First section	Second section	First section	Second section	First section	Second section
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Corn silage	30	30	35	35	30	30	25	30
Alfalfa hay	5	5	5	5	5	5	5	5
Cracked corn	2	2	1	2	1	2	2	2
Ground oats	4	1	3	2	4	4	2	2
Wheat bran	3	1	3	2	2	2	4	2
Oil meal O.P.	2	2	4	2	3	3	4	2

Throughout the experiment the rations consisted of corn silage, alfalfa hay and a grain mixture of cracked corn, ground oats, wheat bran, and old process linseed oil meal.

The length of the experimental period during which any drug was administered was always two days. The check periods were not all of the same length. The plan of the experiment called for an eight day check period before and following the administration of each drug, but the plan could not be adhered

to rigidly. However, the length of the check periods did not vary more than one day either way. The first check period began November 16, 1919, and the last check period ended February 19, 1920.

TABLE 3

Drug administration

DRUG	NUMBER OF COWS	COW NUMBER	DOSAGES AND METHODS OF ADMINISTRATION
Castor oil.....	4	293 323 373 398	One-half pint given in morning and 1 pint in the evening for two days, as a drench
Aloes and rhubarb.	4	298 323 373 398	One bolus of aloes and 2 boli of rhubarb in the evening, and 2 boli of rhubarb in the morning for two days. Each bolus of aloes contained 1 ounce of aloes. The rhubarb bolus contained $\frac{3}{8}\frac{2}{4}$ ounce rhubarb
Potassium iodide..	4	298 323 373 398	Cows 298 and 398 received 3 drams of potassium iodide in 1 quart of water evening and morning for two days. Cows 323 and 373 received 4 drams of potassium iodide in 1 quart of water evening and morning for two days
Strychnine.....	3	298 373 398	Cows 298 and 373 received hypodermically $\frac{1}{4}$ grain strychnine in the evening and $\frac{1}{4}$ grain in the morning for two days. Cow 398 received $\frac{1}{4}$ grain twice a day for two days
Sodium cacodylate	3	298 373 398	Twenty-four grains of sodium cacodylate in 20 cc. of distilled water twice a day for two days, given hypodermically
Urotropin and benzoic acid.....	3	298 373 398	Cow 298 received 2 drams urotropin in 1 quart of water twice a day for two days. Cows 373 and 398 received 2 drams of urotropin and 2 drams benzoic acid in 1 quart of water twice a day for two days

In order to obtain a reasonable idea as to the influence of the drug used, the average daily production of each cow during the check periods immediately preceeding and following the period

TABLE 4

Average daily yields of milk and fat

DRUG	PERIOD	COW 298			COW 323			COW 373			COW 398			AVERAGE		
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		lbs.	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*
Castor oil	Check	14.1	4.85	0.68	10.1	4.14	0.42	24.7	3.70	0.91	16.0	5.16	0.82	16.2	4.38	0.71
	Experiment	14.3	4.27	0.61	10.0	3.51	0.35	25.3	3.51	0.90	15.9	4.43	0.70	16.4	3.92	0.64
Aloes and rhubarb	Check	12.5	4.73	0.59	9.6	3.73	0.36	25.5	3.55	0.91	16.1	4.89	0.79	15.9	4.15	0.66
	Experiment	12.3	4.99	0.61	8.3	4.44	0.37	25.1	3.76	0.90	16.2	5.27	0.85	15.5	4.49	0.69
Potassium iodide	Check	12.1	4.87	0.59	9.1	3.94	0.36	24.7	3.72	0.92	15.2	5.02	0.76	15.3	4.30	0.66
	Experiment	13.2	4.96	0.65	9.0	3.75	0.34	25.2	3.82	0.96	16.2	4.93	0.80	15.9	4.33	0.69
Strychnine	Check	12.2	4.55	0.56				22.4	3.82	0.85	15.1	4.99	0.75	16.6	4.35	0.72
	Experiment	11.9	4.91	0.58				24.0	3.72	0.89	15.6	5.09	0.79	17.2	4.41	0.76
Sodium cacodylate	Check	16.4	4.74	0.54				20.8	3.99	0.83	14.7	5.54	0.81	15.6	4.66	0.73
	Experiment	11.0	5.23	0.57				20.7	4.17	0.86	14.4	5.53	0.78	15.3	4.85	0.74
Urotropin and benzoic acid	Check	10.9	4.91	0.54				19.7	4.10	0.81	14.8	5.52	0.82	15.2	4.76	0.76
	Experiment	10.8	4.74	0.51				20.0	4.50	0.90	14.3	4.89	0.70	15.0	4.68	0.70

TABLE 5

Percentage change in production

DRUG	PERCENTAGE	COW 298			COW 323			COW 373			COW 398			AVERAGE		
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		lbs.	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*
Castor oil	Increase	1						2						1		
	Decrease		12	10	1	15	17		4	1	1	14	15		11	10
Aloes and rhubarb	Increase		5	3		19	3		6	3	1	8	8		8	5
	Decrease	2			14			2						3		
Potassium iodide	Increase	9	2	10				2	3	4	7		5	4	1	5
	Decrease				1	5	6					2				
Strychnine	Increase		8	4				7		5	3	2	5	4	1	6
	Decrease	2							3							
Sodium cacodylate	Increase		10	6					5	4					4	1
	Decrease	3									2		2	2		
Urotropin and benzoic acid	Increase							2	9	11						
	Decrease	1	3	6							3	11	15	1	2	3

of drug administration was obtained. This was used as a basis with which to compare the average daily production of the cow during the period of drug administration.

DISCUSSION OF RESULTS

Castor oil. The castor oil did not produce purging or even noticeable laxativeness in any case. There was a decrease in the percentage of fat and the total fat yielded in every case, and a slight increase in milk in two cases. The decreases in the percentage of fat and the total fat yield were 11 per cent and 10 per cent respectively, with a 1 per cent increase in milk yield. All the cows were thrown off feed, refusing to to eat all their grain for two feeds.

Aloes and rhubarb. The aloes and rhubarb produced an increase in each case in fat percentage and total fat yield, the average increase for the four cows being 8 per cent and 5 per cent respectively. A slight decrease occurred in milk production in three cases, the fourth showing an increase of 1 per cent. The marked increase in the percentage of fat in one case, that of cow 323, can be partially attributed to the fact that the cow went off feed on the administration of the aloes and rhubarb, and consequently, decreased greatly in milk production.

Potassium iodide. The administration of potassium iodide resulted in a variety of changes in the yield of milk, percentage of fat, and total yield of fat. One case resulted in a decrease in milk, fat percentage, and total fat. This cow was off feed, which may account for the decrease in her case, as in the other cases the tendency was upwards. An average increase of four per cent in milk yield, 1 per cent in percentage of fat, and 5 per cent in total fat yield, resulted from the administration of this drug.

Strychnine. The administration of strychnine resulted in a 2 per cent decrease in milk in the case of one cow, and a 3 per cent decrease in fat percentage in the case of one other cow. Aside from these decreases, an increase in milk, fat percentage, and butterfat yield followed the administration of strychnine. The average for the three cows was an increase of 4 per cent in

milk production, 6 per cent in total fat yield, and 1 per cent in the fat percentage. The animals manifested a slight nervousness, which can probably be attributed to the strychnine, but no other abnormal symptoms were noticeable. The fourth cow was eliminated at the beginning of the trial as she was difficult to keep on feed.

Sodium cacodylate. The sodium cacodylate was variable in its influences. In two cases there was an increase in fat percentage and total fat, with a 3 per cent decrease in milk in the case of one cow, and no change in milk yield with the other. In the third case there was a 2 per cent decrease in milk and fat, with no variation in fat percentage. The average for the three cows was a 2 per cent decrease in milk, a 4 per cent increase in fat percentage, and a 1 per cent increase in total fat yield.

Urotropin and benzoic acid. Urotropin was administered to one cow, while the two others were given benzoic acid and urotropin. The urotropin was administered alone to note whether the milk would indicate the presence of formaldehyde, without the use of an acid. A chemical examination indicated a positive test for formaldehyde, without the administration of an acid. Urotropin produced a decrease in milk, fat percentage, and total fat in the case of one cow, and when the benzoic acid was added the same results were obtained in the case of the second cow. In the case of the third cow, given urotropin and benzoic acid, an increase in milk, fat percentage, and total fat resulted. The average for the three cows showed a slight decrease throughout, though the individual variations, especially in the percentage and yield of fat, had been very wide.

SUMMARY

1. The great variations in the results obtained with different cows show that drug administration can not be relied on to favorably influence the yield of milk or butterfat.

2. The only result of much significance obtained was the marked decrease in fat yield and percentage of fat induced by the castor oil.

3. The aloes-rhubarb mixture was the only material administered which produced an increase in fat percentage with every cow. The high average increase obtained here, however, is probably due to the fact that one cow went off feed and decreased greatly in milk production.

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NECESSARY RECORDS IN MILK COST ACCOUNTING[1]

OSCAR ERF

Ohio State University, Columbus, Ohio

DIRECTIONS AND EXPLANATIONS

In securing costs it must be remembered that the figures are of no value unless they represent complete costs. The omission of part of the items or failure to charge them correctly renders the account valueless.

In figuring costs of the dairy, the accounts should be divided into three groups: (1) The bull account; (2) the young stock account; and (3) the producing herd account.

The bull account is finally charged to the young stock account. For illustration: It costs $125 to keep a herd sire for one year. If there are twenty calves then each calf will cost $6.25. This will check off the bull account and place it in the young stock account, which in turn is finally transferred to the producing herd account. For illustration: Add to the cost of $6.25 for service, a cost of $106 for feed, labor and other costs for two years and we have $112.25 which represents the total cost of the calf. The heifer is now charged as a cow to the producing herd at $112.25, thus wiping out the young stock account so that all of expenses are finally carried by the producing herd.

COST ACCOUNT OF THE PRODUCING HERD

This account embraces all cows that have freshened in addition to the dry cows, but does not include heifers or other cows not used for milk production.

This account if not taken according to the individual cow's time should be prorated according to the number of cows in the herd.

[1] This report on records in cost accounting was given by Professor Oscar Erf before the Products Section of the American Dairy Science Association, October 11, 1920.—EDITOR.

In case labor is included in any of the items, such as throwing down hay for the entire herd, a proportional share of the time should be charged to the producing herd. Example: If fifteen minutes are required to throw down hay for the entire herd and one-third is used for the young stock and the bull, then ten minutes of this time should be charged to the producing herd.

In figuring costs transportation from the farm to the shipping point of destination, should not be included in the producing herd account. Milk should always be figured on the basis of cost at the farm.

The cost account is divided into two divisions: (1) The Earnings, (2) The Expenses.

The earnings are grouped under three heads: (1) Milk, (2) Calves, (3) Manure.

The earnings are determined by weighing the milk of the individual cow; estimating the value of the calf at four days of age, or at its actual sale value if sold; and estimating the value of the manure.

The expenses are grouped under three heads: (1) Feed, (2) Labor, (3) Overhead or Other Costs.

The expenses are determined by adding the cost of feed, labor and overhead or other costs.

EXPENSES

(*1*) *Feed*

1. Feeds fed to stock should be priced at the purchase price laid down in the bin at the farm. This includes the cost of the feed plus the unloading and hauling charges and the interest on the investment. Or, if the feed is purchased, it should be valued at the farm sale value (meaning market value less cost of marketing, transportation, storage and collection charges) computed when fed.

2. Feeds having no sale value are to be figured on the cost of production.

3. Silage is valued on the value of standing corn, plus the cost of siloing, plus the interest upon the silo, wear and tear, and depreciation.

4. Permanent pasture should be charged in accordance with the principal used in determining land charges, or it may be replaced value of the average price of farm feeds to produce a similar quantity of milk and butterfat.

5. Crops that are continually harvested and have a sale value should be charged against the livestock at the farm value less the cost of harvesting.

6. Interplanted crops which cannot be harvested should when pastured be charged at the cost of production unless they have a local sale value as pasture.

7. Crops grown primarily for harvesting but pastured incidentally should be charged either at the local rate for such pasture or at the value less the cost of harvesting or any reduction in the yield due to grazing or the value of feed replaced by pasture. If the grazing results in no apparent reduction of yield and there is no local sale price for such pasture, the charge should be that of other feeds replaced.

8. Crop residue and crop waste left in the field should be charged at the local farm value. If no such value exists charge should be the value of other feeds replaced. The same rule should apply to crops grown for greater maturity but grazed incidentally.

(2) *Labor*

Any self respecting farmer should include in the costs of production the proper number of hours required to do the work and should charge it at the current price per hour. If the producer charges his labor at 20 cents an hour when the current price is 30 cents an hour, he is rendering his account valueless.

1. *Milking.* This includes the time required for driving the cows from the paddock or yard near the barn, into the barn; stanchioning them and tying them; getting the utensils such as milk pails, cans, etc.; rinsing them preparatory to milking; cleaning the cows at milking time; washing the udder; spraying for flies; milking the cows; releasing them from the stanchions after milking and taking the milk from the cooler.

2. *Milking machines.* When milking machines are used, in addition to the items listed in the paragraph above are the prepa-

ration of the milking machine; starting of the gasoline engine or motor; oiling the engine; and rinsing the machine before and after milking.

3. *Daily hours for feeding.* This includes the time required in taking the hay from the mow or from the stack; gathering soiling crops daily from the field and any feeds which have no market value; grinding the hay or shredding the stalks; and preparing feed in any manner at the time of feeding. If stalks are gathered from the field, shredded or cut and put in the barn at one operation, the labor should be charged to the value of the stalk. This also includes removing the silage from the silo and feeding it to the cow; and in case it is mixed with the grain, the time required to mix it.

4. *Mixing and feeding grain.* This includes the time required to take grain from the bins or cribs, shelling or grinding, soaking or in any manner preparing these grains and feeding them. It also includes mixing, salting, condiments, etc. If the grain is ground at the mill, the grinding should be charged to the price of the grain, as should also the proportional time for hauling grain to and from the mill and putting it back into the bin. Purchased grains are charged at cost price at the times the bags are emptied or the grain is in the bin. The labor of hauling the grain from the place of purchase should be charged to the cost of the feed, but time required for mixing and feeding is charged under this item.

5. *Watering cows.* This includes the time required to drive cows to and from the watering place when necessary; labor required to pump water or time to care for and start engines for pumping purposes; time to start heaters and care for them; cleaning troughs or water devices, etc.

6. *Driving cows to and from pasture.* This includes getting the cows from the pasture and driving them into a paddock or open court near the barn, and driving them back to the pasture.

7. *Cleaning stables, bedding and currying cows.* Cleaning stables has reference to the daily cleaning and delivering the manure to the pit, wagon, spreader, or depositing in a convenient place where it can be hauled to the field; sweeping stables or

feed alleys; sweeping down cobwebs and cleaning the walls; whitewashing or disinfecting the stable; cleaning out the gutters or drains; hauling and distributing bedding; currying, cleaning, clipping, disinfecting and grooming cows; cleaning yards or paddocks; and spreading straw in the yards.

8. *Washing utensils and care of milk.* This includes assembling and preparation of the cooler wherever necessary or assembling and preparation of the cream separator; time for pumping water; care and starting of engines, motors and pumps for cooling milk and pumping water; taking ice from the ice house and icing milk; rinsing the cooler or separator; cooling the milk; stopping engine; dissembling and washing cooler or separator; starting fires to heat water for washing utensils; and temporary repairing of utensils. In case a milking machine is used it is rinsed in the stable and time should be included for oiling the machine, washing, scalding and disinfecting it.

9. *Hitching up horses and hauling milk.* This includes the time required to hitch up a horse; prepare wagon or truck; loading and unloading of milk; time for hauling to the nearest station; unhitching the horse; unloading the empty cans; and proper preparation of cans and can covers or insulators, used for hauling the milk.

10. *Miscellaneous items.* This includes the time for taking care of sick cows as at the time of calving; milking them until the time when the milk is fit for consumption; greasing and massaging the udder, as in case of gargot, abortion or milk fever; preparing them for service and driving them to and from the breeding pen.

11. *Superintendence and clerical.* This includes time necessary to buy feeds; buy and sell cows to supply the dairy; buy and install equipment; repair equipment; clerical work; marketing milk; figuring rations; attending meetings; correspondence; accounting; and all superintendence and clerical work necessary to the dairy.

12. *Unproductive labor.* This includes all waste labor which is necessary in the operation of milk production, such as loss of time due to weather conditions; time lost due to breakage; unavoidable delay, etc.

13. *Horse labor.* This includes the actual labor of horses used for bringing the feed into the stable, or in some instances hauling soiling crops from the field. When a horse is used for hauling a large amount of feed from the elevator for instance, this should be charged to the cost of the field. This is also true when hay is brought in from the farm and put into the mow in large quantities during haying time. But if the hay stack is located in the field and daily supply brought in to the cows, then the cost of horse labor must be charged. If hay or other roughage is purchased off from the farm, then the cost of horse labor must be charged to the cost of the feed and the value of the feed will be the price paid for it, plus the cost of hauling. Time required for horse labor in delivering milk or gathering the cans daily, or in case of cream production, for delivering the cream, is included in this item. If delivery is done by automobile, then a charge should be made on the basis of commercial rates for hauling, as determined by current prices in the community. Any labor, such as driving to and from towns for emergency, such as medicines, repairs, etc., included under this item.

14. *Transportation expenses.* This includes all expenses incurred in operating trucks, automobiles, etc., for purposes explained under horse labor.

(2) *Other Costs*

1. *Inventories.* The first item under other costs is inventories and this is divided into buildings chargeable to the dairy; equipment chargeable to the dairy; and dairy cattle. The inventory is estimated at the beginning and at the end of the year. The valuation should be placed on the total buildings and equipment and due allowance made for the non-producing portion of the herd. Rise in price of material in buildings and equipment should be taken into consideration and should be prorated on the producing herd. The depreciation must be determined according to the inventory and extreme market prices cannot be taken into consideration, but must be set aside in a separate account. For illustration: A man values his cattle at $150 each, but at the end of the year due to sudden increase in value

of cattle, he sells a number of them for $300 each and values the remainder at the same amount. A substantial increase may be made on the old inventory; however, a sudden rise must be charged to the profit and loss account. The same is true when there is a sudden reduction in price.

2. *Current expense.* This includes all expenses in the care of the producing herd and whenever it involves other cattle or horses, a proportional share is charged to the producing herd.

3. *Cost of repairs.* This includes all nominal repairs but not extensive repairs, as when the wind takes the roof from the barn. Under such conditions an insurance rate should be charged and repairs should be made from the fund set aside for insurance. If no insurance has been provided then the entire cost of repair must be charged to that year's milk, but there is injustice in this method in that it shows an abnormally high cost for that particular year. An insurance rate should be charged on all items possible.

4. *Cost of repairs on equipment.* The same principal holds true in the case of equipment as with repairs on buildings. All extensive repairs on equipment should be charged to insurance.

5. *Insurance.* This should include insurance against fire and storms on all buildings. Insurance on equipment should include accident insurance. Insurance on cows should include insurance against death and benefit insurance as well. That is, if a cow loses a quarter her value is greatly reduced and the amount of depreciation should be covered by insurance. Insurance should be carried against contagious abortion and other diseases. The State provides a special insurance against tuberculosis but in many cases this does not cover the entire loss, so a fund should be set aside for this insurance. Likewise insurance should be carried against depreciation by age.

This is sometimes termed depreciation of cattle but it embraces the actual valuation of the natural decreases. Such insurance should be carried on an animal even though she appreciates in value, for her value appreciates from the time she is two years old until she is five or six and depreciates after she is nine or ten years old. The period of usefulness is rather high unless

insurance is carried on depreciation. Usually a charge of 14½ per cent is made for insurance.

6. *Method of determining the inventory.* Add the items in the inventory at the beginning of the year and add the items in the inventory at the end of the year. Add the credits and all items purchased. Add the credits to the inventory at the end of the year. Subtract the items purchased during the year from the inventory at the end of the year and the difference will be the true inventory of the old material at the end of the year. To find the depreciation, subtract the true inventory of the old material at the end of the year from the inventory at the beginning of the year and divide the difference by the inventory at the beginning of the year. This will give the per cent of depreciation.

For illustration: There are six milk cans on the farm at the beginning of the year, valued at $2 each, making a total inventory of $12 at the beginning of the year. During the year two of these are discarded; one sold for $2 and then new ones bought at $6 a can. At the end of the year the old ones are valued at $1 each, making the total value of the milk cans $21. Twelve dollars is the inventory at the beginning of the year and $21 the inventory at the end of the year. Add the credits—$2—and subtract $18 and there is a balance of $2, the amount of depreciation on cans. Divide by 12 and the per cent of depreciation which in this case is 41, is determined.

To find the inventory of the cows, add the inventories at the beginning of the year and at the end of the year. Add the values of the cows sold. Add the values of cows purchased. Add values of cows sold to the inventory at the end of the year; then subtract the value of the cows purchased. This will give the true inventory at the end of the year.

In valueing cows no extreme values are permitted. That is, a heifer may be appreciated naturally, but the appreciation must not be so great that it will show fictitious credits and lower the price of milk. The appreciation of the heifer must be taken care of from the fact that the heifer requires an extra amount of feed and a lesser amount of milk is produced for the feed consumed, than the mature cow. This loss can be made up by appreciation.

Anything in excess of this will reduce the price of milk. However, cows must be depreciated on their actual decline in value after they have reached the age of maturity which is usually five years.

THE PRODUCING HERD ACCOUNT

This differs from the individual cow account in that it requires less labor and is for the farmer who does not keep a detailed account of his cows. This simplifies the work and is for the purpose of determining the cost of 100 pounds of milk.

In this case the earnings include the milk sold plus the milk used on the farm, the calves and the manure.

The expenses are determined for the entire herd.

The cost of 100 pounds of milk is determined by adding the estimated value of the manure and the calf, subtracting this amount from the total expenses and dividing the difference by the pounds of milk sold plus that used on the farm.

For illustration: A man has ten cows and his expenses for one month are $200. Eight calves were born during the year with an estimated value of $40. The estimated value of the manure is $120, making a total value of $160 for the year or $16.67 for one month. Subtract $16.67 from $200, the total expense and there is left $183.33. Five thousand pounds of milk were sold and 1000 pounds used on the farm, making a total of 6000 pounds of milk. Divide $183.33 by 60 (60 hundred pounds) and the result is $3.05 or the cost of producing 100 pounds of milk on the farm.

If, however, cows are pastured, then manure shall be determined on the basis of actual production. For illustration: When cows are on pasture, the manure value is taken into consideration when estimating the value of the pasture; hence, during that month no credit shall be made for the manure. During the winter when all the manure is collected, full credit should be given for the manure.

FACTORS AFFECTING THE TOTAL BUTTER-FAT CONTENT OF COWS' MILK DURING A PERIOD OF TWO DAYS

W. M. REGAN AND S. W. MEAD

Dairy Department, New Jersey Agricultural Experiment Station, New Brunswick, New Jersey

In the supervision of advanced registry tests the New Jersey Agricultural Experiment Station requires that its supervisor shall see that each cow is "milked dry" at the milking preceding the test period. The supervision of this preliminary milking costs the breeders of pure-bred dairy cattle in New Jersey approximately $2500 each year.

The breed associations and some of the breeders have raised a question as to the necessity of the preliminary milking as a measure in the safe-guarding of the honesty and accuracy of the test. At the last meeting of the Dairy Science Association it was found that out of eleven states, seven require no preliminary milking, two leave the matter to the discretion of the superintendant of advanced registry of the state, and only two require a preliminary milking. It is their claim that thoroughness of milking would not be a factor affecting subsequent tests and consequently, the expense is a needless one. It was for the purpose of obtaining information on this point that the following outlined experiment was planned.

OUTLINE OF EXPERIMENT

The experiment involved the use of four cows in the college herd, two Holsteins, one Jersey, and one Ayrshire. The animals were selected, so far as possible, with regard to uniformity of stage of lactation and gestation, age and quantity of milk produced.

The feeding, housing and general care of the animals did not differ from that of the college herd.

Accurate account was kept of all feed consumed by each of the animals. Weight, height at withers and heart-girth measurements were taken every thirty days in order to have a check in case of any difficulties arising during the experiment. The cows were milked dry twice daily for six days. On the morning of the seventh day only half of the milk was drawn and during the four subsequent milkings the cows were again milked dry.

Samples were taken at each milking and tested for butter-fat. In this way it was possible to obtain an accurate comparison between the average butter-fat test before and after the partial milking. This proceedure was repeated twenty-seven times with the four cows.

It will be noted that tables 1, 2, 3 and 4 do not give the data for every day through-out the experimental period, but only for the milkings which have a direct bearing on the results of the trials and only for those trials in which approximately half of the milk was drawn during the milking at which such a procedure was planned. At the beginning of the experiment, milking machines were used but it was found difficult to calculate the point at which half the milk had been drawn. For this reason it was found advisable to use only hand milking and one man was placed in charge of the animals. In this way more careful attention was given to the milking. This man also did all of the testing thereby eliminating so far as possible any chances of error which might arise through different methods of conducting the Babcock test.

PRESENTATION OF DATA

Table 1, 2, 3 and 4 show the pounds of milk produced, the per cent of butter-fat and the pounds of butter-fat produced by each cow during the four milkings immediately preceding the partial milking, for the partial milking and during the four milkings immediately following the partial milking. Tables 5 and 6 were derived from tables 1, 2, 3 and 4 and show more clearly the result of the partial milking.

TABLE 1

Cow 416; record of milk and butter-fat produced and percent of fat

Milk

MILKING	FEBRUARY 10-12	FEBRUARY 24-26	MARCH 3-5	MARCH 10-12	MARCH 17-19	MARCH 24-26	MARCH 31-APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	9.0	8.4	8.2	6.5	9.5	7.7	7.00
a.m.	11.2	9.0	10.7	9.5	10.5	10.0	8.70
p.m.	9.2	8.7	7.6	9.0	8.8	7.2	6.60
a.m.	11.5	9.1	9.6	9.4	9.8	8.5	9.70
Average..	10.2	8.8	9.0	8.6	9.7	8.4	8.00
Partial milking							
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	7.1	5.5	4.9	4.8	5.0	5.5	5.20
Post period							
	FEBRUARY 13-15	FEBRUARY 27-MARCH 1	MARCH 6-8	MARCH 13-15	MARCH 20-22	MARCH 27-29	APRIL 3-5
p.m.	9.6	10.0	12.6	14.5	12.0	9.5	14.1
a.m.	12.4	8.5	7.8	9.0	9.7	9.1	10.2
p.m.	9.2	7.4	8.0	9.2	8.6	7.0	8.2
a.m.	11.0	8.0	8.7	10.6	12.4	7.0	10.0
Average..	10.6	8.5	9.3	10.8	10.7	8.2	10.6
Percent fat							
	FEBRUARY 10-12	FEBRUARY 24-26	MARCH 3-5	MARCH 10-12	MARCH 17-19	MARCH 24-26	MARCH 31-APRIL 2
Preceding period							
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
p.m.	4.65	6.00	4.78	4.95	4.90	4.95	4.60
a.m.	4.95	4.55	4.45	4.05	4.60	3.90	4.28
p.m.	5.75	5.40	4.75		4.30	4.55	4.35
a.m.	4.05	4.75	4.25	4.30	4.95	3.80	4.45
Average..	4.81	5.15	4.53	4.37	4.69	4.25	4.41
Partial milking							
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	4.28	3.70	3.70	3.90	3.05	3.50	3.35

TABLE 1—*Continued*

Percent fat

MILKING	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
Post period							
p.m.	3.70	5.05	4.58	4.33	4.63	4.93	5.15
a.m.	5.60	5.35	4.48	5.05	5.38	4.58	5.20
p.m.	6.05	4.80	4.00	5.13	4.50	4.08	4.55
a.m.	4.88	3.90	4.33	4.45	4.10	5.20	4.33
Average..	5.07	4.79	4.37	4.67	4.62	4.71	4.85

Butter-fat production

	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	0.4185	0.5040	0.3919	0.3217	0.4655	0.3811	0.3220
a.m.	0.5544	0.4095	0.4761	0.3847	0.4830	0.3900	0.3723
p.m.	0.5290	0.4698	0.3610		0.3784	0.3276	0.2871
a.m.	0.4657	0.4322	0.4080	0.4042	0.4851	0.3230	0.4316
Average..	0.4919	0.4538	0.4093	0.3702	0.4530	0.3554	0.3532

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	0.3038	0.2035	0.1813	0.1872	0.1525	0.1925	0.1742

Post period

	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
p.m.	0.3552	0.5050	0.5770	0.6278	0.5556	0.4683	0.7261
a.m.	0.6944	0.4547	0.3494	0.4545	0.5218	0.4167	0.5304
p.m.	0.5566	0.3552	0.3200	0.4719	0.3870	0.2856	0.3731
a.m.	0.5368	0.3120	0.3767	0.4717	0.5084	0.3640	0.4330
Average..	0.5357	0.4067	0.4057	0.5064	0.4932	0.3836	0.5156

TABLE 2

Cow 322; record of milk and butter-fat produced and percent of fat

Milk

MILKING	FEBRUARY 10-12	FEBRUARY 24-26	MARCH 3-5	MARCH 10-12	MARCH 17-19	MARCH 24-26	MARCH 31-APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p m.	8.9	7.4	8.4	8.0	6.5	7.5	7.00
a.m.	10.9	9.5	10.1	9.2	9.3	10.0	10.00
p.m	8.8	7.6	7.8	8.5	7.0	7.6	6.60
a.m.	11.5	9.3	9.7	8.7	9.5	10.5	10.30
Average..	10.0	8.5	9.0	8.5	8.1	8.9	8.4
Partial milking							
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a m.	5.6	6.0	5.2	4.8	4.5	9.3	5.2
Post period							
	FEBRUARY 13-15	FEBRUARY 27-MARCH 1	MARCH 6-8	MARCH 13-15	MARCH 20-22	MARCH 27-29	APRIL 3-5
p.m.	12.2	10.0	11.5	12.8	13.5	9.1	12.0
a.m.	9.0	10.0	8.5	8.0	8.7	10.4	9.8
p.m.	8.3	7.5	7.3	8.2	8.3	7.3	7.5
a.m.	10.4	10.2	8.9	8.4	10.2	11.0	10.6
Average..	10.0	9.4	9.1	9.4	10.2	9.5	9.9
Percent fat							
	FEBRUARY 10-12	FEBRUARY 24-26	MARCH 3-5	MARCH 10-12	MARCH 17-19	MARCH 24-26	MARCH 31-APRIL 2
Preceding Period							
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
p.m	5.00	5.15	4.88	4.78	4.85	5.05	4.63
a.m.	5.05	5.25	4.70	4.75	4.60	4.60	4.78
p.m.	4.93	5.25	5.33	4.70	4.68	4.83	4.73
a.m.	4.83	5.00	4.80	5.15	4.68	4.63	4.48
Average .	4.94	5.15	4.90	4.84	4.69	4.75	4.64
Partial milking							
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	3.85	3.90	4.00	3.75	2.28	2.80	3.28

TABLE 2—*Continued*

Percent fat

MILKING	FEBRUARY 13-15	FEBRUARY 27-MARCH 1	MARCH 6-8	MARCH 13-15	MARCH 20-22	MARCH 27-29	APRIL 3-5
Post period							
p.m.	6.00	5.70	5.30	4.70	5.40	4.70	5.85
a.m.	6.05	5.80	5.43	5.55	5.35	5.10	5.45
p.m.	5.13	5.20	5.08	5.90	4.40	4.75	4.90
a.m.	4.78	4.95	4.78	5.40	4.65	5.05	4.78
Average..	5.51	5.42	5.15	5.30	4.99	4.92	5.28

Butter-fat production

	FEBRUARY 10-12	FEBRUARY 24-26	MARCH 3-5	MARCH 10-12	MARCH 17-19	MARCH 24-26	MARCH 31-APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	0.4450	0.3811	0.4099	0.3824	0.3152	0.3787	0.3241
a.m.	0.5504	0.4987	0.4747	0.4370	0.4278	0.4600	0.4780
p.m.	0.4338	0.3990	0.4157	0.3995	0.3276	0.3670	0.3121
a.m.	0.5554	0.4650	0.4656	0.4480	0.4446	0.4861	0.4614
Average..	0.4961	0.4359	0.4414	0.4167	0.3788	0.4229	0.3939

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	0.2156	0.2340	0.2080	0.1800	0.1026	0.2604	0.1705

Post period

	FEBRUARY 13-15	FEBRUARY 27-MARCH 1	MARCH 6-8	MARCH 13-15	MARCH 20-22	MARCH 27-29	APRIL 3-5
p.m.	0.7320	0.5700	0.6095	0.6016	0.7290	0.4277	0.7020
a.m.	0.5445	0.5800	0.4615	0.4440	0.4654	0.5304	0.5341
p.m.	0.4257	0.3900	0.3708	0.4838	0.3652	0.3467	0.3675
a.m.	0.4971	0.5049	0.4254	0.4536	0.4743	0.5555	0.5066
Average..	0.5498	0.5112	0.4668	0.4957	0.5084	0.4650	0.5275

TABLE 3

Cow 71; record of milk and butter-fat produced and percent of fat

Milk

MILKING	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	14.4	12.1	13.8	13.8	13.7	11.8	13.0
a.m.	16.0	14.4	17.0	17.0	17.4	16.5	17.2
p.m.	13.8	12.3	13.9	14.7	12.7	14.0	13.4
a.m.	17.8	13.5	17.1	16.5	17.0	16.5	17.2
Average..	15.5	13.0	15.4	15.5	15.2	14.7	15.2
Partial milking							
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	9.0	11.0	8.5	8.8	7.5	7.6	8.6
Post period							
	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
p.m.	10.1	16.0	20.3	22.0	20.8	17.0	19.7
a.m.	16.1	14.0	14.9	15.8	17.1	14.7	19.2
p.m.	12.2	11.4	14.4	15.6	14.1	12.6	13.6
a.m.	16.9	18.1	16.5	17.6	18.0	17.9	17.6
Average..	13.8	14.8	16.5	17.7	17.5	15.5	17.5
Percent fat							
	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
Preceding period							
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
p.m.	3.60	3.30	2.98	3.10	3.23	3.48	3.30
a.m.	3.63	3.50	3.03	2.83	3.05	2.83	2.83
p.m.	3.45	3.60	3.48	3.20	3.15	3.33	3.45
a.m.	3.50	3.45	3.18	2.80	3.18	2.83	3.10
Average..	3.54	3.46	3.16	2.96	3.14	3.07	3.14
Partial milking							
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	2.70	2.50	2.45	2.33	1.65	1.95	2.20

TABLE 3—*Continued*

Percent fat

MILKING	FEBRUARY 12–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
				Post period			
p.m.	3.35	3.75	3.50	3.45	3.85	3.83	3.20
a.m.	4.00	3.48	2.80	3.28	3.30	3.50	3.20
p.m.	3.55	3.35	3.65	3.30	3.05	3.50	3.05
a.m.	3.40	3.00	3.15	3.15	2.78	3.78	2.78
Average..	3.59	3.38	3.28	3.30	3.27	3.67	3.06

Butter-fat production

	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
				Preceding period			
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	0.5184	0.3993	0.4112	0.4278	0.4425	0.4106	0.4290
a.m.	0.5808	0.5040	0.5151	0.4811	0.5307	0.4669	0.4867
p.m.	0.4761	0.4428	0.4837	0.4702	0.4000	0.4662	0.4623
a.m.	0.6230	0.4657	0.5437	0.4620	0.5406	0.4669	0.5332
Average..	0.5495	0.4529	0.4884	0.4602	0.4784	0.4526	0.4778

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	0.2430	0.2750	0.2082	0.2050	0.1237	0.1482	0.1892

Post period

	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
p.m.	0.3383	0.6000	0.7105	0.7590	0.8008	0.6511	0.6304
a.m.	0.6440	0.4872	0.4172	0.5182	0.5643	0.5145	0.6144
p.m.	0.4331	0.3819	0.5256	0.5148	0.4300	0.4410	0.4148
a.m.	0.5746	0.5430	0.5197	0.5544	0.5004	0.6766	0.4892
Average..	0.4971	0.5029	0.5432	0.5866	0.5738	0.5708	0.5372

TABLE 4

Cow 59; record of milk and butter-fat produced and percent of fat

Milk

MILKING	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 31–APRIL 2
Preceding period						
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	11.5	10.7	10.5	10.5	9.9	10.1
a.m.	12.5	13.0	12.6	12.0	12.6	11.8
p.m.	11.0	10.8	10.1	10.0	9.1	9.2
a.m.	13.7	12.0	12.8	11.8	12.5	12.0
Average.....	12.1	11.6	11.5	11.0	11.0	10.7
Partial milking						
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	APRIL 3
a.m.	7.7	10.2	6.3	6.5	6.1	6.3
Post period						
	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	APRIL 3–6
p.m.	10.3	11.0	12.6	13.5	12.4	7.9
a.m.	12.6	12.3	11.2	11.6	11.6	12.6
p.m.	10.0	10.2	9.8	11.6	10.4	9.5
a.m.	12.5	13.4	11.5	12.2	12.3	11.6
Average.....	11.3	11.7	11.2	12.2	11.6	10.4

Percent fat

	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 24–26	MARCH 31–APRIL 2
Preceding period						
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
p.m.	3.90	3.78	3.95	4.03	3.85	4.50
a.m.	3.70	3.88	3.60	3.80	3.75	3.85
p.m.	4.13	4.20	4.20	3.90	3.80	3.90
a.m.	4.05	4.10	4.05	3.88	3.83	3.95
Average.....	3.94	3.98	3.93	3.89	3.80	3.92
Partial milking						
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	APRIL 3
a.m.	2.60	3.20	2.55	2.88	2.40	2.80

TABLE 4—*Continued*

Percent fat

MILKING	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	APRIL 3–5
Post period						
p.m.	3.88	4.50	5.00	4.70	5.15	5.60
a.m.	4.45	4.23	4.25	4.18	3.90	4.85
p m.	4.20	4.15	4.70	4.70	3.78	3.78
a.m.	3.90	4.00	4.30	3.83	4.05	4.10
Average.....	4.11	4.21	4.57	4.35	4.24	4.53

Butter-fat production

	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 31–APRIL 2
Preceding period						
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	0.4485	0.4044	0.4147	0.4231	0.3811	0.4090
a.m.	0.4625	0.5044	0.4536	0.4560	0.4725	0.4519
p.m.	0.4543	0.4536	0.4242	0.3900	0.3458	0.3588
a.m.	0.5548	0.4920	0.5184	0.4578	0.4787	0.4740
Average.....	0.4800	0.4636	0.4527	0.4317	0.4195	0.4234

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	APRIL 3
a.m.	0.2002	0.3264	0.1606	0.1872	0.1464	0.1764

Post period

	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	APRIL 3–5
p.m.	0.3996	0.4950	0.6300	0.6345	0.6386	0.4424
a.m.	0.5607	0.5202	0.4760	0.4848	0.4524	0.6112
p.m.	0.4200	0.4233	0.4606	0.5452	0.3931	0.3591
a.m.	0.4875	0.5360	0.4945	0.4672	0.4981	0.4756
Average.....	0.4669	0.4936	0.5152	0.5329	0.4955	0.4720

TABLE 5

Showing differences between milk and fat production and per cent butter-fat before and after partial milking

TRIAL NUMBER	MILK	FAT	BUTTER-FAT
	Cow 416		
	pounds	*per cent*	*pounds*
1	+0.4	+0.26	+0.0438
2	−0.3	−0.36	−0.0471
3	+0.3	−0.16	−0.0036
4	+2.2	+0.30	+0.1362
5	+1.0	−0.07	+0.0402
6	−0.2	+0.46	+0.0282
7	+2.6	+0.44	+0.1624
	Cow 322		
1		+0.57	+0.0537
2	+0.9	+0.27	+0.0753
3	+0.1	+0.25	+0.0254
4	+0.9	+0.46	+0.0790
5	+2.2	+0.30	+0.1296
6	+0.6	+0.17	+0.0421
7	+1.5	+0.64	+0.1336
	Cow 71		
1	−1.7	+0.05	−0.0524
2	+1.8	−0.08	+0.0500
3	+1.1	+0.12	+0.0548
4	+2.2	+0.34	+0.1264
5	+2.3	+0.13	+0.0954
6	+0.8	+0.60	+0.1182
7	+2.3	−0.08	+0.0594
	Cow 59		
1	−0.8	+0.17	−0.1031
2	+0.1	+0.23	+0.0300
3	−0.3	+0.64	+0.0625
4	+1.2	+0.46	+0.1012
5	+0.6	+0.44	+0.0760
6	−0.3	+0.61	+0.0486

+ = Increase of post period over preceding period.

THE EFFECT ON PERCENT FAT

The 108 milkings following the 27 partial milkings showed an average test of 0.27 per cent higher than the 108 milkings preceding the 27 partial milkings. It will be noticed that during some of the trials there was a slight decrease in per cent fat, but each of the four animals showed an increase when all of the trials were considered. The figures apparently show no preference to breed in that one Holstein made an average increase of 0.425 in per cent of butter-fat while the other made only 0.154 increase in per cent of butter-fat. However, the average for these two animals was higher than either the Jersey or the

TABLE 6

Average increase in milk and butterfat production and per cent fat for each individual during seven trials

COW NUMBER	MILK	FAT	BUTTER-FAT
	pounds	*per cent*	*pounds*
59	0.08	0.425	0.0508
71	1.25	0.154	0.0645
322	.88	0.38	0.0769
416	.857	0.124	0.0514
Average.....	.766	0.270	0.0609

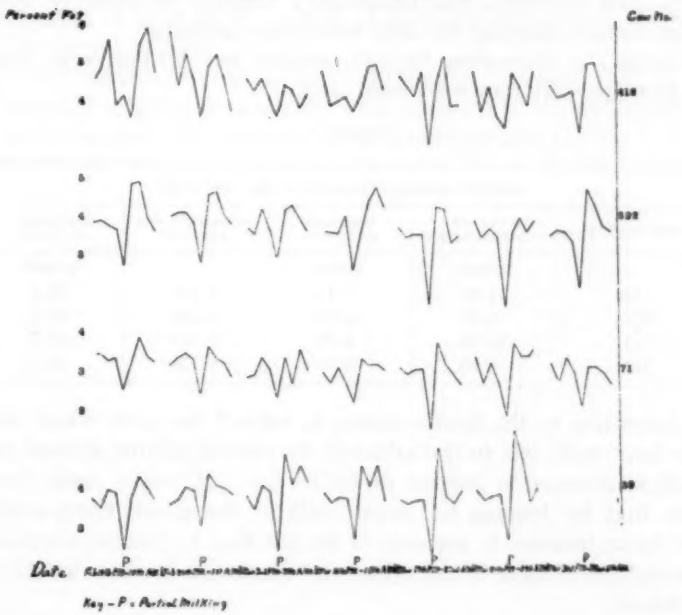
Ayrshire. The increase in the fat percentage shown by the Jersey and Ayrshire averaged 0.380 and 0.124 respectively.

The average increase of 0.27 per cent in fat would not seem very large. However, in the case of a cow producing 20,000 pounds of milk per year this increase of 0.27 per cent would add 54 pounds to her yearly butter-fat production. During several of the trials the increase was far in excess of the average. Table 5 shows that in one trial there was an increase of over 6 per-cent and in 10 others there was an average increase of over 0.53 per cent. Taking this into consideration the date collected would indicate that while the average for all trials was only 0.27 it would be possible, however, to obtain a much larger increase in percent of butter-fat.

Graph 1 reveals an interesting feature of the experiment. It would be expected that the highest fat percentage would be reached at the milking following the partial milking. Graph 1 shows that this is not always the case, since out of the 27 trials there were 12 in which the butter-fat percentage was

GRAPH NO. I

SHOWING FAT TESTS BEFORE AND AFTER PARTIAL MILKING



higher at the second milking than it was for the milking immediately following the partial milking.

THE EFFECT ON THE PRODUCTION OF MILK

The average milk production for the 108 milkings following the 27 partial milkings averaged 0.766 pounds more than the 108

milkings preceding the 27 partial milkings. The increase is very slight when we consider that it was made during four milkings, which would mean an increase of only 0.191 pounds per milking.

The average production of the four cows before the partial milking was 10.98 pounds. On the average 3.8 pounds of milk were left in the udder of each cow at the partial milking. Since there was an increase of only 0.191 pounds of milk it is assumed that the rest of the milk was either reabsorbed in the udder or that milk secretion was temporarily checked or possibly both were factors affecting the four subsequent milkings.

Table 7 is interesting though possibly not conclusive in view of fact that only four cows were used.

TABLE 7

Pounds of milk left in udder estimated in per cent of normal production compared with the average increase in per cent of fat

COW NUMBER	AVERAGE MILK PRODUCTION	MILK LEFT IN UDDER	INCREASE IN PER CENT FAT	MILK LEFT IN UDDER
	pounds	*pounds*		*per cent*
59	11.31	4.13	0.425	36.5
322	8.77	2.97	0.380	33.8
71	14.92	6.18	0.154	41.3
416	8.95	3.52	0.124	39.3

According to the figures shown in table 7 the cows which had the least milk left in the udder at the partial milking showed the highest increase in percent of butter fat. It would seem from this that by leaving too much milk in the udder there would not be an increase in per cent of fat but that by leaving a certain percentage of milk in the udder the maximum increase would be obtained.

SUMMARY

It was found possible in this experiment to increase the percentage of butter-fat in milk during a period of two days by leaving half of the milk in the udder during the milking prior to the two-day period. Although the average increase in percent of butter-fat was only 0.27, the data collected would seem

to indicate that it is possible to get an increase of over 0.5 in percent of butter-fat.

The highest fat percentage was not always reached at the milking following the partial milking. Out of the 27 trials there were 12 in which the highest fat percentage was reached the second milking after the partial milking.

If in advanced registry work a practice was made of leaving a part of the milk in the udder prior to the two day test; our figures would indicate that such a practice could not be detected by a study of the cows milk record; since there was an average increase of only 0.766 pounds of milk for the period following the partial milking.

The data collected in this experiment indicates that a preliminary milking is necessary as a measure in the safe-guarding of the honesty and accuracy of advanced registry testing.

YEASTS AND OIDIA IN HIGH-GRADE EXPERIMENTAL BUTTER

WILLIAM R. NORTH, JR. AND GEORGE F. REDDISH[1]

Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.

In studying butter, Redfield[2] has proposed a routine microscopic method of counting yeasts and oidia as correlated in some degree at least with the quality of the cream used in its manufacture. This method is based upon the examination of the curd-whey mixture separating out when the sample of butter is melted at 45°C. One-cubic centimeter samples of this mixture are removed to sterile containers and smears are made by transferring 0.01 cc. samples of this mixture to slides with the Breed type of pipette, for microscopic study. The results shown in table 1 are selected from experiments made to test the accuracy of this method.

These results based on the number of yeasts found in 10 microscopic fields, check as closely as those usually obtained by the official plate method, and therefore indicate that yeasts are fairly evenly distributed throughout the butter. Counts of this kind, check fairly closely when the totals are high as in these samples. Much greater differences occur in successive examinations of samples containing very low numbers of yeasts.

These counts were based on numbers found in 100 microscopic fields. Each cell found was counted.

The results indicate that yeasts are somewhat more evenly distributed than are the oidia. The mycelial character of Oidium lactis tends to result in more uneven distribution of the

[1] The authors wish to express their appreciation to Dr. Charles Thom of the Microbiological Laboratory of the Bureau of Chemistry for his kindly assistance in the preparation of this paper.

[2] In case the curd does not completely separate from the butterfat after fifteen minutes at 45°C., slow centrifuging of the tube for about one minute while the melted butter is at the above temperature will bring all the curd to the bottom of the tube. It is essential that there be a clear separation of the curd from the butterfat.

vegetative elements of the oidia than is found to be true in studying yeasts.

The commercial samples of butter and cream used by Redfield represented chiefly lower grades, hence failed to establish a relation to cream and butter of high quality. To obtain information as to the abundance of these forms in the higher grades of cream, a series of studies were made during the summer of 1920 at the Experimental Creamery Laboratory of the Dairy

TABLE 1

Yeasts in samples from different parts of the same butter

NUMBER	TUBE I	TUBE II	TUBE III	TUBE IV
538 B	1,060,000	1,200,000	2,350,000	1,500,000
540 B	810,000	950,000	550,000	850,000

TABLE 2

Counts from different smears of the same sample of curd-whey mixture

NUMBER	(a)	(b)	(c)	ORGANISMS
301 B1	2,280,000	2,790,000	2,490,000	Yeasts
302 B1	150,000	160,000	585,000	Oidia
303 B2	250,000	225,000	245,000	Yeasts
232 B1	55,000	75,000		Oidia
232 B3	225,000	260,000		Oidia
236 B1	1,370,000	750,000	860,000	Oidia
236 B2	610,000	780,000	2,140,000	Oidia
237 B1	160,000	55,000	25,000	Oidia
237 B1	340,000	215,000	155,000	Yeasts

Division, Bureau of Animal Industry of this Department at Grove City, Pennsylvania, which is conducted in close cooperation with the commercial manufacture of pasteurized sweet cream butter of exceptionally high grade. The samples taken for examination were thus obtained from commercial vats of cream which were subsequently made into butter scoring 93 or over. Samples of this butter, as freshly made, were examined microscopically, and reserve samples were packed in 1-pound cans sealed and stored for later examination.

Table 3 gives the microscopic and cultural results obtained in examining 14 samples of cream which in every case produced butter scoring 93 or 94 (see table 4). Since the microscopic method used (see Redfield) introduces a factor of 500,000, one organism in each microscopic field would represent 500,000 per cubic centimeter of material examined. In the table therefore "−5000" represents failure to find a single organism in examining 100 fields. Since no oidia were found with the microscope the

TABLE 3

Microscopic and plate counts of yeasts, oidia and bacteria in sweet raw cream

NUMBER OF CREAM	MICROSCOPIC COUNT			PLATE COUNT WHEY AGAR 30°C.—5 DAYS		
	Yeasts	Oidia	Bacteria*	Yeasts	Oidia	Bacteria*
200 C	−5,000	−5,000	61,000,000	110	30	32,240,000
201 C	−5,000	−5,000	40,000,000			
202 C	5,000	−5,000	117,000,000	3,800	500	49,000,000
203 C	65,000	−5,000	100,000,000	2,100	125	95,500,000
204 C	5,000	−5,000	39,000,000	1,200	100	39,500,000
205 C	75,000	−5,000	44,500,000	40	40	35,500,000
206 C	−5,000	−5,000	110,000,000	850	100	
207 C	5,000	−5,000	53,500,000			
208 C	−5,000	−5,000	34,000,000			
210 C	25,000	−5,000	132,000,000	1,100	100	
211 C	7,500	−5,000	80,000,000	350	−100	
213 C	5,000	−5,000	60,000,000	5,200	200	75,000,000
214 C	30,000	−5,000	100,000,000	895	25	85,000,000
215 C	−5,000	−5,000	100,000,000	4,600	100	

* Microscopic count of bacteria wherever made in this paper was based on groups of bacteria rather than on the enumeration of individuals. The figures for yeasts and oidia include every cell found.

counts of viable organisms in the column reporting the cultural examinations, represent the actual numbers of viable oidia present with a maximum of 500 per cubic centimeter. These figures show that even in cream passed by physical examination as high in quality both yeasts and oidia are present in numbers sufficient to account as inoculating material for the tremendous numbers found later in samples of the same cream when subjected to incubation.

TABLE 4

Microscopic counts of yeasts and Oidium lactis in cream, fresh butter, same butter after transit and after storage

NUMBER OF BUTTER	FRESH BUTTER				AFTER TRANSIT TO WASHINGTON*				AFTER STORAGE AT 22° F.†			
	Score	Salt	Yeasts	Oidia	Age when examined	Score	Yeasts	Oidia	Time in storage	Score	Yeasts	Oidia
		per cent			*days*				*days*			
200 B	93	2.0	−5,000	−5,000	13	94	2,020,000	−5,000	155	94.0	705,000	−5,000
201 B	94	2.2	−5,000	−5,000	13	93	1,730,000	−5,000	154	93.5	470,000	−5,000
202 B	94	2.0	−5,000	−5,000	13	93	540,000	−5,000	156	92.0	585,000	−5,000
203 B	94	2.4	−5,000	−5,000	13	93	215,000	−5,000	155	93.0	260,000	−5,000
204 B	94	3.2	−5,000	−5,000	19	94	215,000	−5,000	161	93.0	380,000	−5,000
205 B	94	2.2	−5,000	−5,000	11	94	450,000	−5,000	155	93.0	60,000	−5,000
206 B	94	2.4	−5,000	−5,000	23	93	4,240,000	−5,000	157	92.0	6,230,000	−5,000
207 B	94	2.0	−5,000	−5,000	21	94	340,000	−5,000	164	93.0	1,250,000	−5,000
208 B	94	3.3	−5,000	−5,000	19	94	165,000	−5,000	166	93.0	130,000	−5,000
210 B	94	2.0	−5,000	−5,000	25	93	1,085,000	−5,000	180	93.0	1,440,000	−5,000
211 B	93	2.0	−5,000	−5,000	19	92	1,425,000	−5,000	180	93.0	350,000	−5,000
213 B	94	2.2	−5,000	−5,000	26	93	8,150,000	−5,000	180	93.0	3,815,000	−5,000
214 B	94	3.0	−5,000	−5,000	22	93	5,290,000	−5,000	179	93.0	3,770,000	−5,000
215 B	94	2.4	−5,000	−5,000	15	92	750,000	−5,000	170	92.5	370,000	−5,000

* After one to seven days at 40–45° F., transit to Washington, and one to three days at 12°F.
† Placed in storage in Washington.

The absence of oidia in the microscopic counts of high-grade cream shows marked contrast to the large numbers found in most of his samples by Redfield. The occasional presence of yeasts in numbers under 100,000 was clearly unaccompanied by physical evidence of lowered quality. The cream was sampled from a large pasteurizing vat before heating had begun, and represents the mixed product of many producers. Titration showed the acidities of these samples to vary from 0.15 to 0.17 per cent, but no cream showing physically noticeable acidity was accepted. These vats of cream represented mixed lots which varied in age from a few hours to forty-eight hours old, but all of which had been well-cooled on the farm. Microscopic counts before pasteurizing showed bacterial numbers already running from 34,000,000 to 132,000,000. Experimental samples from certain of these commercial vats of cream were removed to the laboratory and held for further study at 70 to 80° F. These samples were titrated from time to time and pasteurized at the desired acidities which ran in series from 0.20 to 0.34 per cent and required increasing periods up to six hours for their development, and were accompanied by microscopic counts of bacteria running to 300,000,000. Cream in the condition at which these samples were taken into the creamery, would sour quickly if not pasteurized or refrigerated promptly.

TREATMENT OF CREAM AND BUTTER

The mixed cream was pasteurized in a large vat at 145° for thirty minutes. After cooling, it was kept at 45°F. in the same vat for about twelve hours. The cream was protected from contamination during that time. It was then churned sweet in a large revolving churn. No starter was used.

Samples were taken directly from the churn for immediate microscopic examination and for storage in canned form. The results of this examination are combined with the findings of subsequent examinations to form table 4. The microscopic counts of yeasts and oidia are seen to be less than 5000 per cubic centimeter of the curd-whey mixture, in every sample. In other words, no yeasts nor oidia were found when 100 fields of

the microscope were examined. Cultures made from these samples showed small numbers of yeasts and oidia; the maximum number was roughly 300 yeasts and 100 oidia per gram of butter, but both groups were found present in viable condition in the samples examined. Bacterial colonies found in the cultures ranged from 10,000 to 130,000. The samples taken from the churn and canned were first stored in the creamery refrigerator at 40 to 45° F. for one to seven days, then shipped by express to Washington, D. C. It was not possible to control the temperatures at which the butter was held in transit. The exposures were supposed to have been approximately as follows: About five hours at ordinary baggage car temperature, about eight hours at express-car refrigerator temperature, about one hour at summer temperatures during transportation from the railroad station to the Bureau of Chemistry. All samples were then stored at 22°F.

After one to three days storage in Washington two cans of each series were opened and examined. The differences in score found were not great and might represent the differences in opinion of the judges. All these samples showed an increased microscopic count of yeasts at this time. Varied increases are noted. Since these samples were shipped at different times during the summer months, they were not subjected to the same conditions of transportation or for the same period of storage at 45° F. in Grove City. No increase in oidia appeared. This organism does not grow in salted butter. The large increases in numbers of yeasts found in examining these samples are apparently only important as showing a multiplication factor in this butter subjected to temperatures above freezing. The indications are that the actual number of yeasts in a sample of butter can not be correlated with the condition of the cream unless the examination is made immediately after churning, or unless the butter is kept thoroughly chilled or unless the yeasts have been all killed by pasteurization. Samples of these same lots were held at 22° F. for five to six months and again examined (also in table 4). The scores remain practically unchanged. The oidia counts are unchanged. A few increases in numbers of yeasts are offset by a larger number of decreases.

TABLE 5

Storage butter held two weeks at 50°F.

NUMBER OF BUTTER	SCORE WHEN REMOVED FROM STORAGE	MICROSCOPIC COUNT		SCORE AFTER TWO WEEKS IN THE ICE-BOX	MICROSCOPIC COUNT		ORGANISMS DEVELOPING PER CUBIC CENTIMETER OF CURD-WHEY MIXTURE ON WHEY AGAR IN 5 DAYS AT 30° C.		ORGANISMS DEVELOPING PER GRAM OF BUTTER ON WHEY AGAR IN 5 DAYS AT 30° C.	
		Yeasts	Oidia		Yeasts	Oidia	Total	Yeasts	Total	Yeasts
200 B	94.0	705,000	−5,000	92.0	4,332,000	−5,000	2,100,000	2,100,000	520,000	520,000
201 B	93.5	473,000	−5,000	91.5	360,000	−5,000	−10,000	−10,000	−10,000	−10,000
202 B	92.0	585,000	−5,000	92.5	470,000	−5,000	10,000	10,000	−10,000	−10,000
203 B	93.0	260,000	−5,000	92.0	800,000	−5,000	350,000	350,000	50,000	50,000
205 B	93.0	60,000	−5,000	91.0	395,000	−5,000	70,000	−10,000	66,000	−1,000
206 B	92.0	6,230,000	−5,000	88.0	12,550,000	−5,000	4,300,000	4,300,000	410,000	410,000
207 B	93.0	1,250,000	−5,000	88.0*	1,790,000	−5,000	60,000	60,000	30,000	30,000
208 B	93.0	130,000	−5,000	89.0†	100,000	−5,000	910,000‡	—	40,000‡	—
210 B	93.0	1,440,000	−5,000	93.0	1,750,000	−5,000	170,000	170,000	100,000	100,000
215 B	92.5	370,000	−5,000	91.0	6,860,000	−5,000	1,000,000	1,000,000	20,000	20,000

* Metallic, bordering on fishy flavor.

† Stale flavor.

‡ Bacteria predominated so it was impossible to find the number of yeasts.

TABLE 6

Microscopic examination of wholesale samples of butter in New York

NUMBER OF BUTTER	SCORE	COMMENTS OF SCORER	NEW YORK RESULTS (G. F. S.). Microscopic count	
			Yeasts	Oidia
831	95		−10,000	−10,000
810	94		70,000	−10,000
824	94	Sweet cream butter	7,250,000	−10,000
830	94	Creamery	−10,000	−10,000
845	94		−10,000	−10,000
809	93	Sweet, clean	100,000	170,000
814	93	Creamery	150,000	50,000
825	93		180,000	−10,000
828	93	Sweet cream	−10,000	−10,000
842	93	Sweet, clean	375,000	50,000
846	93		120,000	20,000
849	93	Creamy	10,000	−10,000
803	92	Sweet	1,600,000	−10,000
811	92		350,000	−10,000
815	92		220,000	10,000
821	92	Unsalted	240,000	−10,000
822	92		700,000	−10,000
829	92		−10,000	−10,000
843	92		−10,000	−10,000
813	91	Weedy	80,000	30,000
818	91	Slightly lardy	10,000	−10,000
823	91	Flat, low salt, Holland	5,100,000	−10,000
844	91		−10,000	−10,000
848	91	Tainted, unclean	10,000	−10,000
801	90	Little oily	650,000	30,000
805	90	Little oily	150,000	−10,000
812	90	Little oily	260,000	20,000
816	90	Little oily	40,000	−10,000
826	90	Curdy, lardy	180,000	380,000
850	90	Little curdy, acid	350,000	300,000
857	90	Flat	1,450,000	−10,000
827	89	Slightly oily, weedy	550,000	−10,000
851	89	Old flavor	240,000	200,000
856	89	Acidy	3,050,000	850,000
804	88	Unclean, sour	550,000	130,000
806	88	Slightly fishy	400,000	100,000
807	88	Oily, stale, slightly fishy	250,000	140,000
817	88	Oily, slightly fishy	100,000	−10,000
853	88	Sour	150,000	550,000

TABLE 6—*Continued*

NUMBER OF BUTTER	SCORE	COMMENTS OF SCORER	NEW YORK RESULTS (G. F. R.)	
			Microscopic count	
			Yeasts	Oidia
802	87	Stale, oily, little fishy	100,000	60,000
808	87	Fishy flavor	200,000	450,000
820	87	Fishy flavor	120,000	−10,000
847	87	Distinctly fishy	340,000	120,000
862	87	Whey butter	4,650,000	100,000
819	86	Pronounced fishy flavor	−10,000	−10,000
852	84	Stale, weedy, tallowy	1,600,000	350,000
855	84	Rank, weedy, very high salt	400,000	300,000
860	84	Pronounced fishy	480,000	40,000
858	83	Rank, stale, sour	220,000	120,000
859	83	Rank, stale, weedy	1,550,000	850,000
861	83	Tallowy	1,450,000	400,000

Cans representing 10 of the samples in this series were then removed from cold storage and held in the ice-refrigerator at about 50° F. for two weeks and examined (table 5). No development of oidia is shown, but the numbers of yeasts show a positive increase in 5 samples. The score of these samples shows deterioration but not correlated with the numbers of yeasts found, since increases of yeasts are in some cases unaccompanied by change in score and changes in score are in other samples not accompanied by increased numbers of yeasts.

Counts of colonies developing in whey-agar are given in table 5 for these 10 samples. In these cultures yeasts dominated. Bacteria appeared in only one sample in appreciable numbers. One sample showed no colonies of any organism in the ten thousandth of a cubic centimeter. Wort agar plates, however, showed viable oidia in every sample in numbers varying from 10 to 600 per cubic centimeter. This species was clearly held in check by salt in the butter.

For comparison with this group of samples table 6 is introduced to include a series of samples of butter of unknown history taken in wholesale warehouses in New York. In this series the general contrast between low counts of oidia in higher scoring

TABLE 7

NUMBER	CREAM						FRESH BUTTER		
	Period of inoculation	Temperature	Flavor of cream	Acidity	Microscopic count		Microscopic count		Score
					Yeasts	Oidia	Yeasts	Oidia	
220 C1	18 hours	75°–80°F.	Clean acid	0.58	−5,000	−5,000	−5,000	−5,000	92
221 C1	18 hours	75°–80°F.	Clean acid	0.51	10,000	−5,000	60,000	−5,000	92
228 C1	24 hours	75°–80°F.	Clean acid	0.63	−5,000	−5,000	−5,000	−5,000	91
219 C1	24 hours	75°–80°F.	Clean acid	0.67	−5,000	−5,000	10,000	−5,000	92
223 C1	2 days	75°–80°F.	Clean acid	0.70	85,000	125,000	40,000	165,000	89 Stale typical centralizer
209 C3	4 days	75°–80°F.	Slightly stale	0.79	790,000	770,000	350,000	275,000	89 Stale dish rag flavor
232 C3	4 days	75°–80°F.	Slightly stale	0.87	30,000	880,000	25,000	260,000	88 Stale
203 C1	5 days	75°–80°F.	Slightly cheesy	0.82	400,000	640,000	230,000	1,320,000	90 Stale old cream
229 C2	5 days	50°F.	Clean acid	0.64	30,000	−5,000	−5,000	−5,000	92
236 C1	9 days	75°–80°F.	Medium stale	0.96	1,880,000	3,210,000	105,000	996,000	87 Very stale old cream

lots and very high counts in the low scoring lots is maintained. No absolute correlation, however, is established between count of either group and score.

Experiments to test further the significance of the numbers of oidia found are brought together in table 7. These samples of cream probably averaged twenty-four hours old at the time they were taken from the commercial vat. After twenty-four hours in the laboratory (at 70 to 80° F.) no sample showed 5000 oidia per cubic centimeter. After two days, marked increase was found for both yeasts and oidia accompanied by curdling from the development of acid bacteria. The numbers of oidia in both cream and butter rises rapidly with the age of the cream except in sample 229 C2, which was held in the refrigerator at 50° F. for comparison. These numbers compare with similar results given by Redfield. Under the butter-making conditions of these experiments, microscopic counts of above 5000 oidia in the curd-whey mixture indicated the use of cream both sour and stale in flavor in the manufacture of the product.

In general, these studies indicate that a microscopic count of yeasts and oidia by the Redfield method can be made to show the relative numbers of these organisms present in samples of butter.

No sample of high-grade cream and no sample of salty butter made from such cream showed 5000 oidia in these experiments.

In the first-grade sweet cream used, the number of yeasts usually fell below 5000, but certain samples contained up to 75,000 yeasts per cubic centimeter without showing physical signs of deterioration.

Under the condition of handling represented in these Grove City samples of cream which showed less than 100,000 yeasts and less than 5000 oidia, bacterial multiplication had already reached figures of 34,000,000 to 132,000,000. Cream showing these numbers of bacteria is close to the turning point in flavor.

In a commercially salted butter, there is an apparent correlation between the presence of oidia in appreciable numbers (50,000 and over is suggested) and the use of old stale or deteriorated cream in its manufacture.

THE VOLATILE ACIDS AND THE VOLATILE OXIDIZABLE SUBSTANCES OF CREAM AND EXPERIMENTAL BUTTER

L. W. FERRIS, H. W. REDFIELD AND W. R. NORTH

Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.[1]

In judging the fitness of cream for butter-making, the odor is generally considered as one of the most important factors. Van Slyke and Baker[2] observe that there is a characteristic flavor due, not to lactic acid, but to the presence of some volatile compound which appears in milk even before it begins to taste sour. In this study, the volatile acids and the "oxidizability value"[3] of cream and butter have been considered in their relation to the quality of cream and of the butter made from different grades of cream and the changes that take place during storage under different conditions.

A method for determining the rancidity of fat and oils, is given by Issoglio,[4] who found that when the "oxidizability value" is above 15, that the fat is rancid or that some other change has taken place. Brill and Parker,[4] working on cocoanut oil, found that although some samples, which were undoubtedly rancid, gave a low oxidizability value, however, when this value was high, the oil was always rancid. Kerr[5] found results that, in the main, confirmed the standards set by Issoglio, but, observing that most of the oxidizable substances are soluble in water, preferred to wash the fat or oil with water and oxidize the washings rather than distil with steam.

In order to measure the oxidizable substances produced by decomposition in cream and butter, the original sample, in

[1] Acknowledgment is hereby made to L. Jones, J. I. Palmore, Miss Scott, Miss Offutt and Miss Dean of this Bureau, for assistance in chemical analyses and to the Butter Experts of the Dairy Division of this Department for scoring the samples of butter.

[2] Free lactic acid in sour milk. Jour. Biol. Chem., xxxv, 178.

[3] Annali. chim. Applic., 1916, vi, 1–18.

[4] Philippine Jour. Sci., 1917, xii, 95–110.

[5] Jour. Ind. & Eng. Chem., x, no. 6, p. 471.

each case, was subjected to steam distillation and the distillate oxidized according to the procedure given by Issoglio. Since, in this case, other substances than fat are present, it could not be expected that the values obtained would be strictly comparable to those given by Issoglio, but the values found on cream and on butter should represent, in each case, the relative amount of volatile, oxidizable substances present.

In table 1 are shown the results obtained on 14 samples of butter[6] from sweet cream made at the experimental creamery of the Dairy Division, Bureau of Animal Industry, of this Department, at Grove City, Pennsylvania. Samples of the regular run butter were sealed in 1 pound tins and sent to Washington, where the butter was scored and examined. For comparison with these results, table 1 also gives data on experimental samples made from a portion of the cream taken from the regular run and held until a slight acidity developed. These samples are marked "Bl", in each case. On each sample the volatile acids, without saponification, were determined as follows: To 50 grams of sample in a 500-cc. flask, such as used for the determination of nitrogen by the Kjeldahl method, 5 cc. of 25 per cent phosphoric acid and 100 cc. of boiled distilled water were added, and the mixture steam distilled at such a rate that 100 cc. of distillate were collected in ten minutes. Another determination of volatile acid was made, treating the sample as above, except that instead of steam distillation, the flame was applied directly to the 500-cc. flask and 100-cc. distilled over in thirty minutes. The distillate, in each case, was titrated to the phenolphthalein end point with tenth normal sodium hydroxide.

An inspection of table 1 shows that although there is scarcely any perceptible difference in the quality of the butter when fresh, as shown by the score, yet, in each case, there is an increase in volatile acids from the experimental samples over the amount found in the "regular run" butter from the same cream. In all cases, the results found by the direct distillation were higher than by the steam distillation, although practically the

[6] These same samples are included in the work by North and Reddish, Yeasts and Oidia in High-grade Experimental Butter, loc. cit.

TABLE 1

Showing results on fresh butter made at Grove City, 1920

SAMPLE NUMBER	ACIDITY OF CREAM	BUTTER SCORE AT FACTORY	VOLATILE ACIDS CUBIC CENTIMETERS OF N/10 PER 100 GRAMS		OXIDIZABILITY VALUE	LACTOSE
			Steam distillation.	Direct distillation		
						per cent
200 B	0.17	93	0.2	0.4	0.4	0.41
201 B	0.16	94	0.3	0.8	0	0.44
202 B	0.16	94	0.2	0.4	0	0.36
203 B	0.16	94	0.2	0.4	0	0.39
204 B	0.17	94	0.2	0.6	2.2	0.34
205 B	0.17	94	0.2	0.4	0	0.37
205 B1	0.40	94	0.7	1.6	1.9	0.35
206 B	0.16	94	0.3	0.4	1.4	0.37
207 B	0.16	94	0.2	0.4	1.3	0.34
207 B1	0.24	94	0.5	0.6	2.5	0.46
208 B	0.16	94	0.4	0.8		0.35
208 B1	0.25	93	0.5	1.1	1.5	0.36
210 B	0.16	94	0.2	0.4	1.7	0.36
210 B1	0.29	94	0.3	0.6	1.3	0.35
211 B	0.17	94	0.2	0.4	1.6	0.36
211 B1	0.23	93	0.3	0.6	1.2	0.26
213 B	0.15	94	0.2	0.5	1.6	—
213 B1	0.31	94	0.4	0.8	0.6	0.31
214 B	0.16	94	0.3	0.5	0.9	0.34
214 B1	0.30	94	0.4	0.7	0.6	0.37
215 B	0.17	94	0.2	0.4	0	0.31
215 B1	0.27	93	0.4	0.6	0	0.35
Sweet cream butters—"B:"						
Maximum			0.4	0.8	2.2	0.44
Minimum			0.2	0.4	0	0.31
Mean			0.2	0.5	0.9	0.36
Experimental butters—"B1:"						
Maximum			0.7	1.6	2.5	0.46
Minimum			0.3	0.6	0	0.26
Mean			0.4	0.8	1.2	0.35

Samples 209 and 212 were yeast experiments and hence not included in this table.

same difference between different samples is found by each procedure. The oxidizability value on the sweet cream butter varied from 0 to 2.2, and, on the experimental butter in table 1,

from 0 to 2.5, the difference not being appreciable, since the experimental error was generally about 0.5.

Table 2 shows the results obtained on duplicate portions of butters examined in table 1, after being held in cold storage at 22° F. for five to six months and again followed by holding in the

TABLE 2

Showing results on butters made at Grove City, 1920, and held in storage

SAMPLE NUMBER	FIVE TO SIX MONTHS IN STORAGE AT 22°F.				SIX TO SEVEN MONTHS IN STORAGE AT 22°F., THEN IN ICE BOX TWO WEEKS			
	SCORE	Volatile acids cubic centimeters of N/10 per 100 grams		OXIDIZABILITY VALUE	SCORE	Volatile acids cubic centimeters of N/10 per 100 grams		OXIDIZABILITY VALUE
		Steam	Direct			Steam	Direct	
200 B	94	0.5	0.5	0.7	92	0.2	0.6	2.0
201 B	93½	0.4	0.6	0	91½	0.4	0.7	1.2
202 B	92	0.6	0.7	0.9	92½		0.8	1.2
203 B	93	0.2	0.7	0.6	92		0.6	0.6
204 B	93	0.5	0.5	0.6				
205 B	93	0.4	0.5	1.0	91	0.5	0.6	2.0
205 B1	91	1.2	2.1	1.5				
206 B	92	0.4	0.6	1.4	88	0.5	0.7	1.3
207 B	93	0.3		0.6	88		0.8	1.4
207 B1	91½	0.6	1.2	1.2				
208 B	93	0.6	0.8	0.2	89		1.0	1.0
208 B1	93	0.5	1.4	0.2	86	0.6	1.0	1.4
210 B	93	0.4	0.6	*4.1	93		0.6	2.9
210 B1	93	0.4	1.0	1.9	90	0.4	0.9	3.2
211 B	93	0.3	0.7	1.6				
211 B1	93	0.4	1.2	2.7				
213 B	93	0.4	0.9	0.6				
213 B1	93	0.4	1.3	1.2	88	0.8	1.2	1.0
214 B	93	0.3	1.0	1.8				
214 B1	93	0.5	1.7	0.6	91	0.5	0.8	1.2
215 B	92½	0.2		0	91		0.9	1.0
215 B1	92	0.4	2.2	0.3				

* Exceptionally high, may be due to experimental error.

ice box two weeks to approximate the conditions of retail distribution. By comparing the sweet cream butter with the experimental butter in table 2, it is seen that, in general, after storage there is the same difference that was found when the

samples were fresh. The score on these butters, after being kept at the temperature of an ordinary ice box for two weeks, was generally somewhat lower than when the butters were first taken from cold storage. However, there was not a corresponding significant increase in volatile acids.

TABLE 3

Résumé of results from tables 1 and 2 showing changes during storage

		VOLATILE ACIDS CUBIC CENTIMETERS OF N/10 PER 100 GRAMS		OXIDIZABILITY VALUE
		Steam	Direct	
Sweet cream butters				
Maximum	Fresh	0.4	0.8	2.2
	Storage	0.6	1.0	*4.1
	Ice box	0.5	1.0	2.9
Minimum	Fresh	0.2	0.4	0
	Storage	0.2	0.5	0
	Ice box	0.2	0.6	0.6
Mean	Fresh	0.2	0.5	0.9
	Storage	0.4	0.7	1.0
	Ice box	0.4	0.8	1.4
Experimental butters				
Maximum	Fresh	0.7	1.6	2.5
	Storage	1.2	2.2	2.7
	Ice box	0.8	1.2	3.2
Minimum	Fresh	0.3	0.6	0
	Storage	0.4	1.0	0.2
	Ice box	0.4	0.8	1.0
Mean	Fresh	0.4	0.8	1.2
	Storage	0.6	1.5	1.2
	Ice box	0.6	1.0	1.7

*See footnote table 2.

Table 3 shows the maximum, minimum and average values found on the sweet cream butter and the experimental butter when fresh and after the two periods of storage. There is a slight but noticeable increase on both the sweet cream butter

TABLE 4

Showing results on experimental butters made at Grove City, 1920

NUMBER	ACIDITY OF CREAM	TIME WHEN ANALIZED	SCORE WHEN ANALIZED	VOLATILE ACIDS AS CUBIC CENTIMETERS OF N/10 PER 100 GRAMS		OXIDIZABILITY VALUE	LACTOSE
				Steam distillation	Direct distillation		
							per cent
217 B1	0.35	Fresh	91	0.5	1.1	0.4	0.29
		Storage	92½	0.8	2.4	1.6	
		Ice box	86		2.2	1.5	
218 B1	0.45	Fresh	91	0.6	1.3	1.8	
		Storage	92½	0.7	2.2	2.4	0.30
		Ice box	87		1.9	1.0	
221 B1	0.51	Fresh	92	0.6	1.3	1.4	0.27
		Storage	92	0.8	1.6	1.7	
		Ice box	89		1.8	0.4	
222 B1	0.55	Fresh	92	0.6	1.3	0.9	
		Storage	93	0.8	1.4	0.9	0.21
		Ice box	89		1.7	1.0	
220 B1	0.58	Fresh	92	0.6	1.5	1.3	0.21
		Storage	93	0.7	1.4	1.1	
		Ice box	86	1.2	1.7	1.4	
216 B1	0.60	Fresh	90	0.7	1.4	0.5	0.27
		Storage	93	0.8	1.6	2.1	
		Ice box	91	1.0	1.5	1.2	
225 B1	0.60	Fresh	90½	0.9	1.5	1.3	0.28
		Storage	92	1.1	1.3	0.9	
		Ice box	89		2.0	0.3	
226 B1	0.62	Fresh	92	0.8	1.6	1.0	0.21
		Storage	92	1.1	1.7	0.6	
		Ice box	89		2.5	2.1	
228 B1	0.63	Fresh	91	0.7	1.3	0.6	
		Storage	92	1.0	1.7	0.6	0.19
		Ice box	89		2.2	1.0	
224 B1	0.65	Fresh	91	0.8	1.5	2.9	
		Storage	92	1.0	2.1	3.0	0.22
		Ice box	88		2.5	0.9	

TABLE 4—*Continued*

NUMBER	ACIDITY OF CREAM	TIME WHEN ANALYZED	SCORE WHEN ANALYZED	VOLATILE ACIDS AS CUBIC CENTIMETERS OF N/10 PER 100 GRAMS		OXIDIZABILITY VALUE	LACTOSE
				Steam distillation	Direct distillation		
							per cent
219 B1	0.67	Fresh	92	0.8	1.4	1.1	
		Storage	93	1.0	2.4	1.6	0.35
		Ice box	91½	1.1	1.6	0.9	
227 B1	0.67	Fresh	91	0.8	1.5	0.6	
		Storage	92	0.8	1.5	0.3	0.23
		Ice box	89		2.3	1.5	
Average		Fresh		0.7	1.4	1.2	
		Storage		0.9	1.8	1.4	0.25
		Ice box		1.1	2.0	1.1	

Cream 223 was held a greater length of time and not included in this table.

and the experimental butter during storage, the sweet cream butter showing a value, after six to seven months in cold storage and two weeks in the ice box, about equal to that of the fresh butter made from cream in which a slight amount of acidity had developed before churning. The maximum oxidizability value found at any time on the sweet cream butter was 4.1 and 3.2 on the above experimental butters. The next to the highest result on sweet cream butter was 2.9, the higher figure being possibly due to experimental error.

Table 4 shows the results obtained on twelve samples of butter made at Grove City from portions of cream which had been held from a few hours to twenty-four hours until the acidity noted in the table had developed, when it was reduced with milk of lime to approximately 0.25 per cent and the cream pasteurized and churned. In each case, the cream appeared to have a clean acid flavor. In six of the samples, the yeast count (microscopic) did not exceed 5000 per cubic centimeter in the cream when ready to churn; six showed counts varying from 10,000 to 30,000 yeasts and all of the samples showed less than 5000 oidia. The volatile acid figures on these samples were generally slightly higher than found on the experimental butters in table 1, made

TABLE 5

Showing volatile acid determination on cream and butter analyzed in Denver Laboratory, 1919

SAMPLE NUMBER	GRADE OF CREAM	ACIDITY OF CREAM, PER CENT LACTIC ACID	SCORE OF BUTTER	VOLATILE ACIDS, DIRECT DISTILLATION			
				Cubic centimeters N/10 per 100 grams		On water basis	
				Cream	Butter	Cream	Butter
1	Slightly sour, medium weedy	0.58	91.75	6.4	2.2	11.3	14.5
	Pasteurized		92.0	5.4	1.6	9.7	11.8
	Starter added		91.25	6.2	2.0	10.2	11.6
2	Slightly sour, medium weedy	0.61	91.5	6.4	1.4	9.4	9.7
	Pasteurized		92.75	5.8	1.6	8.8	12.1
	Starter added		92.5	7.0	1.8	9.9	11.3
3	Medium sour and vinegary	0.99	87.75	7.0	3.8	12.2	20.3
	Pasteurized		87.75	5.2	3.4	9.1	23.7
	Starter added		88.5	7.0	2.2	11.4	12.1
	Neutralized		89.0	6.4	2.2	10.5	14.3
	Neutralized and pasteurized		89.5	8.4	1.8	13.7	11.8
	Neutralized, pasteurized, and starter added		90.5	8.6	1.5	13.4	10.1
4	Sour, medium vinegary, slightly stale	1.07	87.0	6.1	2.2	9.5	13.7
	Pasteurized		86.75	5.2	2.1	8.2	15.3
	Starter added		88.0	6.4	2.1	9.6	14.7
	Neutralized		88.25	7.6	2.2	11.6	13.2
	Neutralized and pasteurized		88.25	6.3	1.9	9.7	12.5
	Neutralized, pasteurized, and starter added		89.5	7.6	1.6	11.3	9.7

5	Actively boiling, medium yeasty and vinegary, slightly stale	1.26	87.0	7.2	2.6	12.4	10.5
	Pasteurized		87.0	6.6	3.0	11.5	10.9
	Starter added		88.0	7.0	1.8	11.5	9.1
	Neutralized		88.5	6.6	2.0	11.1	11.7
	Neutralized and pasteurized		88.5	6.5	2.8	10.9	18.3
	Neutralized, pasteurized, and starter added		89.5	9.4	4.6	—	26.9
6	Foamy, high acid, medium vinegary, stale, bitter, slightly cheesy	1.53	87.5	7.2	22.	11.0	12.9
	Pasteurized		86.0	5.4	1.8	8.4	9.9
	Starter added		87.0	6.6	2.4	9.8	13.1
	Neutralized		85.25	7.2	2.7	12.4	14.8
	Neutralized and pasteurized		86.0	13.6	3.5	20.5	23.7
	Neutralized, pasteurized, and starter added		86.5	7.6	3.7	11.0	28.5
7	High acid, high vinegary, medium stale, cheesy and rancid, slightly bitter	1.35	84.25	8.4	2.9	12.7	9.1
	Pasteurized		86.75	4.8	1.6	7.5	9.3
	Starter added		87.25	5.8	1.8	8.8	9.5
	Neutralized		88.0	9.0	3.2	13.2	14.4
	Neutralized and pasteurized		88.0	8.0	6.6	11.8	41.4
	Neutralized, pasteurized, and starter added		88.5	10.2	3.6	14.6	18.3
8	High vinegary, rancid, bitter, stale, slightly greasy and cheesy	1.25	85.25	6.7	2.2	11.0	12.8
	Pasteurized		84.5	6.4	2.0	12.1	12.6
	Starter added		83.5	9.4	2.8	16.1	14.6
	Neutralized		86.75	7.2	2.2	13.9	12.0
	Neutralized and pasteurized		86.0	8.8	2.0	16.4	10.2
	Neutralized, pasteurized, and starter added		87.0	9.0	2.0	15.9	14.7

TABLE 6

Results on cream and butter analyzed at Denver Laboratory, 1918

NUMBER	GRADE OF CREAM	CREAM			BUTTER		
		Microscopic count		Oxidizability value	Volatile acids as cubic centimeters, N/10 per 100 grams sample Steam distillation	Oxidizability value	Volatile acids as cubic centimeters, N/10 per 100 grams. Steam distillation
		Yeasts	Oidia				
C 23	Sweet, raw	2,600,000*	−100,000	1.6	0.6		
C 14	Sweet, raw	200,000	−100,000	3.0	0.6		
C 16	C 15 and starter	−100,000	−100,000	4.1	0.7	2.4	0.4
C 24	C 23 and starter	600,000	−100,000	4.1	1.3	0.6	0.4
C 26	C 25 neutralized, pasteurized, and starter	260,000	−100,000	4.5	0.3	2.7	0.5
C 7	Composite "first grade"	600,000	300,000	4.6	2.3		
C 25	Sour, raw, part C 24	260,000	1,000,000	5.6	2.4		
C 12	Composite "first grade"	900,000	160,000	6.0	2.2		
C 32	Sour, clear flavor	365,000†	18,000†	6.4	2.0		
C 15	C 14, pasteurized	800,000	−100,000	7.0	0.6		
C 4	Very bitter	300,000	300,000	7.1	2.8		
C 19	C 18, pasteurized	−100,000	400,000	7.9			
C 20	C 19 and starter	−100,000	540,000	9.4		4.1	0.4
C 18	C 17, neutralized			9.7			
C 17	Sour, raw, other half of C 14	−100,000	200,000	10.1	3.1		
C 21	Composite "first grade"	−100,000	−100,000	13.8	2.7	4.9	0.7
C 5	Slightly rancid	1,710,000	1,320,000	17.9	13.0		
C 34	Stale and cheesy	5,000,000†	2,400,000†	18.5	3.7		
C 28	C 27, pasteurized	6,400,000	600,000	27.0		6.8	1.8
C 31	Sour, greasy flavor	2,000,000†	*24,500	28.6	3.1		

C 10	Composite "first grade"	1,000,000	600,000	29.3	3.3		
C 8	Very stale, slightly yeasty	1,200,000	240,000	29.8	6.5		
C 3	Sour, clean flavored	1,080,000	660,000	30.2	2.9		
C 6	Vinegary, high acid	3,720,000	1,440,000	34.3	2.6		
C 9	Very cheesy and thick	540,000	720,000	40.9	53.4		
C 22	"Second grade"	600,000	400,000	41.1	1.7	7.5	0.6
C 13	Sour, "Second grade"	8,200,000	600,000	43.2	3.8		
C 27	Sour, raw "second grade"	4,600,000	800,000	43.4	5.7		
C 33	Rancid and slightly yeasty	1,700,000†	240,000†	44.1	11.5		
C 2	Very stale	4,200,000	300,000	47.3	6.2		
C 29	Yeasty, had foamed very badly	12,800,000	260,000	62.0	3.4		
C 11	Too poor to use for buttermaking	18,480,000	2,100,000	70.3	3.6		
C 1	Very yeasty	5,760,000	120,000	71.7	3.3		
C 30	Very high acid	4,600,000†	390,000†	78.2	3.6		

* This result is out of line and H. W. R. who had charge of the work suggests that it probably is an error.

† These are not microscopic counts but are viable counts per cubic centimeter of cream on wort agar incubated five days at 30°C.

TABLE 7

Showing results on experimental butters made at Grove City, 1920

NUMBER	CREAM HELD		YEASTS, MICROSCOPIC COUNT		TYPE YEAST	BUTTER SCORE	OXIDIZABILITY VALUE	VOLATILE ACIDS AS CUBIC CENTIMETERS N/10 PER 100 GRAMS		LACTOSE
	Days	Temperature	Cream	Butter				Steam	Direct	
										per cent
234 B5.....	3	Room	190,000	20,000	Inert	88	0.3	0.8	1.5	0.21
Storage.....				25,000		91	4.3	1.0	1.5	
Ice box.....				30,000		90	0.3		1.7	
234 B1.....	3	Room	5,000	−5,000	Check, pasteurized	90	0.5	0.6	1.3	0.20
Storage.....				−5,000	cream	91	0.6	0.6	1.0	
Ice box.....				−5,000		90½	0.6		1.7*	
234 B4.....	3	Room	4,150,000	1,210,000	Dextrose fermenting	89	0.6	0.6	2.0	0.26
Storage.....				40,000		91½	1.8	0.7	1.3	
Ice box.....				140,000		91	1.5		1.8	
229 B2.....	5	10°	30,000	−5,000	Raw cream	92	0.8	0.6	1.3	0.21
Storage.....				180,000		91	1.2	0.7	1.3	
Ice box.....				165,000		89*	2.0	0.9	1.6	
233 B1.....	2	25–30°	−5,000	−5,000	Check, pasteurized	92	0.9	0.5	1.1	0.20
Storage.....				−5,000	cream	91	0.3	0.7	1.4	
Ice box.....				−5,000		89	0.6		1.5*	
233 B2.....	2	25–30°	3,300,000	920,000	Lactose fermenting	89	0.9	1.6	2.7	0.19
Storage.....				575,000	pasteurized cream	87	1.5	1.7	3.0	
Ice box.....				450,000		87*	0.7		3.4*	

209 B3.....	3	30–36°	790,000	35,000	Largely inert, raw	89	2.2	0.8	1.6	0.20
Storage.....				500,000	cream neutralized	88	1.7	1.3	2.2	
Ice box.....				280,000	and pasteurized	86	1.3	1.5	2.2	
209 B2.....	3	35°	12,820,000	5,220,000	Torulas phaerila, lac-	91	4.8	0.9	1.5	0.20
Storage.....				5,140,000	tose splitting	89	5.4	1.2	1.9	
Ice box.....										
212 B2.....	5	25–30°	14,000,000	7,725,000	Lactose splitting	86	6.6	0.4	1.2	0.08
Storage.....	2	10°		12,475,000		90	9.1	0.6	1.5	
Ice box.....				3,140,000		83	10.1	0.6	1.4	
209 B1.....	7	20°	19,400,000	13,300,000	Torula sphaerila, lac-	86	10.2	0.7	1.6	0.13
Storage.....				9,780,000	tose splitting	88	11.0	1.1	1.6	
Ice box.....				1,680,000		87	7.7	1.0	1.8	
234 B3.....	3	Room	11,100,000	3,650,000	Torula creamonis,	88	10.4	1.6	2.5	0.11
Storage.....				1,650,000	lactose splitting	87	8.1	1.6	3.4	
Ice box.....				3,300,000		86	7.7	2.5	3.8	
234 B2.....	3	Room	14,500,000	5,600,000	Tortula sphaerila,	87	10.7	1.0	2.1	0.10
Storage.....				8,900,000	lactose splitting	85	9.7	1.0	2.5	
Ice box.....				5,200,000		87*	9.0		2.5*	
212 B1.....	5	25–30°	13,000,000	18,300,000	Lactose splitting	86	15.3	0.7	1.4	0.04
Storage.....				14,450,000		89	19.6	0.5	1.7	
Ice box.....				3,500,000		87	24.4	0.8	1.6	

* These samples were not put in ice box before analyses.

from cream containing a slight amount of acidity which was not reduced before pasteurization and churning. The oxidizability value showed practically no change during the two periods of storage, all values being lower than found on the sweet cream butters in table 1.

Table 5 shows the volatile acid determination and score on butter made from cream received at a commercial creamery at Denver during the summer of 1919. It is seen that the volatile acid determination on these butters is higher, in every case, than that given for the butter made from sweet cream at Grove City, but is approached by the experimental butter from slightly soured cream. Columns 7 and 8 in table 5 show the volatile acids on cream and the corresponding butters calculated to a water basis. These results are greater on the butter in 30 cases and less in 10. It is evident that although the butter may contain some wash water, in addition to the water from the buttermilk, there is a greater proportion of volatile acids to water in the butter than in the cream, in the majority of cases. This may be explained by the fact that volatile acids may be dissolved in the fat as well as in the aqueous portions of the cream.

In table 6 are shown the microscopic count of yeasts, the oxidizability value and volatile acid determinations on samples of cream secured from the above mentioned creamery at Denver in 1918. The samples are arranged according to ascending oxidizability values. There is seen to be some agreement between the count of yeasts and the oxidizability value, both determinations being higher on the poorer samples. The volatile acids are also generally higher on the samples that show greater physical signs of decomposition.

Seven samples of butter were made from portions of the above cream and the oxidizability value and volatile acid figure are shown in columns 7 and 8 of the same table. There is a noticeable lower oxidizability value and volatile acid figure on the butter than on the corresponding cream. It is evident that a greater portion of the volatile acids and the oxidizable substances are removed from the cream during the process of buttermaking, although more remain in the butter from cream showing

higher amounts than in butter from cream showing lower volatile acids and oxidizability value.

In order to understand more fully the significance of yeasts in cream and butter, portions of the regular run cream received at the Grove City Creamery were inoculated with different types of yeasts which originally were isolated from foamy or stale cream. The cream was held at given temperatures for three to five days, then churned in the experimental room of the creamery and the butter sealed in cans and sent to Washington for analysis. Samples of raw cream and pasteurized cream that were not inoculated were held and churned under the same conditions to serve as checks on the yeast experiments. The results are shown in table 7. Each sample was examined when fresh, after five to six months in storage and after six to seven months in storage and two weeks in the ice box. The samples are arranged in order of ascending oxidizability values when fresh. It is seen that there is a rather definite relation between the lactose splitting yeasts and the oxidizability value, the latter being high and the lactose very low, on the samples of butter made from cream which contained the higher numbers of lactose splitting yeasts.

CONCLUSIONS

The volatile acids in 14 samples of commercial sweet cream butter scoring 93 to 94, was found to be 0.2 to 0.4 and 0.5 to 0.8 cc. N/10 per 100 gram sample as determined by the two methods of procedure used in this work. The score on these butters, after being kept in cold storage five to six months, was, in general, about one point lower than when they were fresh and the volatile acid figure was about twice as large. After six to seven months, the butters were removed from cold storage and kept at about 15° for two weeks, this causing a decided drop in score but, however, no corresponding significant increase in volatile acids.

It has been found that there is a noticeable difference between the amount of volatile acids found in the sweet cream butter and the amount found in butter made from clean acid cream, the acidity of which had been reduced before pasteurization. In these experiments, an oxidizability value on butter greater than 5, indicated that the butter was made from cream which had contained a large number of lactose splitting yeasts.

THE VALUE OF A TITRATION TEST FOR ACIDITY AT THE RECEIVING PLATFORM

R. S. FLEMING AND J. H. NAIR

Research Laboratories, Merrell-Soule Company, Syracuse, New York

Recently the maintenance of an acidity standard for fresh milk by condenseries and powdered milk manufacturers has been the object of adverse criticism, based on the established fact that any titration test applied to milk fresh from the cow will indicate an apparent acid condition, which cannot be due to lactic acid, the cause of sour or curdled milk, since the presence of this acid indicates bactericidal action on the milk sugar, a process requiring a lapse of more or less time, according to conditions. Brew (1) has pointed out that this apparent acidity may be as high as 0.25 per cent and yet the milk be processed successfully, though his evidence on that score is negative. Sommers and Hart (2) found in one herd variations on titrable acidity of 0.102 to 0.257 per cent, 52 per cent being above 0.18 per cent, and showed that this bears no relation to the heat coagulation of milk. McInerney (3) found one herd of five cows varying from 0.175 to 0.205 per cent acidity with a composite of 0.19 per cent, and in another mixed herd averages of 0.123 to 0.18 per cent according to breed, with milk from individual cows as high as 0.22 per cent. Van Dam (4) holds that titrating milk leads to wrong conclusions as this measures "potential" acidity, while hydrogenion methods measure the "actual" acidity. Henkel (5), in 10,000 determinations on the milk of individual cows, found variations of 0.1375 to 0.225 per cent, though mixed herd milk had much narrower limits. Baragiola (6) emphasizes the necessity of differentiating between the degree of acidity or concentration of the hydrogenion, expressed in millimoles per liter, and the acid content (total acid, titrable acid, or acid value), expressed in cubic centimeters of normal solution or grams of lactic acid per liter.

The cause of the acid reaction of fresh milk to phenolphthalein has been the object of much investigation, which has resulted in narrowing down the probabilities to two or three sources, or a combination of them. Van Slyke and Bosworth (7) have presented good evidence to substantiate their theory that the apparent acidity is due to the acid phosphates present. Richmond (8) attributes it partly to acid phosphates and partly to dissolved carbon dioxide, though Van Slyke and Baker (9), on the contrary, found that the degree of acidity, as measured by titration tends to decrease with increasing CO_2 content, a condition which Baker and Breed (10) believe is due to the entrance of bicarbonate from the blood of the cow. Bordas and Touplain (11) investigated the titrable acidity, with phenolphthalein, of milk serum, the coagulum containing the insoluble salts, the casein plus the insoluble salts, and the pure casein separated by the alcoholic method. They concluded that the original acidity is due to casein and that no free acid or acid salts exist in milk at the outset. Bordas (12) made further studies and reported that the increase in acidity is due to casein liberated from combination with calcium by the formation of calcium lactate.

This conflicting evidence as to the cause of titrable acidity in fresh milk is of less importance from the standpoint of factory practice than the question of the justice of an acid standard to the factory patrons. If it is true that any considerable number of cows or any one breed of cattle consistently give milk which has a higher titrable acidity than the standard maintained or if the acid test fails to measure the quality of the milk at the receiving platform, the contention of Brew, Hart and others that manufacturers of milk products are in error in maintaining a rejection test based on titrable acidity must be acknowledged and every effort bent toward development of some other test which may distinguish poor milk with more certainty and yet be as rapid of manipulation, as the titration method. Up to the present time no substitute has been devised which meets the latter requirement, the vital one from the manufacturing standpoint. This being the status of the question, the attention of this laboratory was turned to an investigation of the titrable acidity of individual cows and of herds.

The practical experience of a number of milk inspectors was reviewed at the outset and the gleanings summarized into three pertinent facts. First, that the average acidity of herd composite milk as received at the factory was wel below 0.18 per cent, though it was probably true that individual cows of certain herds or breeds gave milk higher than that in acidity. Second, that milk was not rejected on the basis of titrable acidity alone, for an acid test was resorted to only when the odor and flavor of the milk suggested to the experienced inspector that it was questionable. In other words, the acid test is applied mainly as an adjunct to the senses of the trained inspector. This is in line with the best practice of the day. As Hunziker (13) states:

> Experience has shown that, while it is necessary for the condenseries to decide on a maximum acidity of milk above which all milk be rejected, the nose and the palate of the experienced inspector are better criterions than the acid test alone, as to the fitness of milk for condensing. Acid tests are valuable in the case of uncertainty and suspicion as to the quality of any given can of milk. . . . . What has been stated concerning the necessity of high quality of fresh milk in the successful manufacture of condensed milk is equally true in the manufacture of milkpowder. . . It is especially essential that it arrive at the factory perfectly sweet, since acidity tends to lower the solubility of the finished product.

This has been confirmed by our own experience during the past twelve years, during which approximately 10,000,000 cans of milk have been taken in at our receiving platforms. During the flush of the past season an average of 12,000 cans were handled daily, with complete freedom from curdled milk or sour cream. Third, our wide experience has demonstrated clearly that it is impossible to manufacture a heavy cream of less than 0.09 to 0.095 per cent acid or a light cream of less than 0.11 to 0.115 per cent from milk testing 0.17 per cent at the receiving room. Before this fact had been established thousands of pounds of fresh cream became sour during transportation to market. This shipping quality of the fresh cream is an important item. It has been repeatedly demonstrated that heavy cream of 0.10 per cent or a light cream of 0.12 per cent acid may

be apparently in excellent shape when it leaves the factory, but it invariably sours, more quickly in the warm months, before it reaches the retail customer. To insure a cream that will stand up in such shape as to meet the exact demands of the trade, it is essential that the milk as received at the factory be below 0.17 per cent titrable acid. More important, probably, than the souring of this fresh cream is the high acid flavor and the greater tendency toward curdling which appears in milk powdered from fluid milk of high acidity. Maintaining an uniformly high standard of quality in powdered milk means efforts beginning at the farm and this necessitates constant supervision of production conditions. The acid titration test provides one method of checking up on these, as any marked bacterial growth or lack of proper cooling is reflected in increased acidity. Long experience has shown that high acid milk taken in at the receiving platform continues to develop acidity so rapidly that milk powder dried from it has a peculiarly disagreeable acid flavor and, when used for cooking, will curdle easily.

To ascertain definite facts concerning the apparent or titrable acidity of fresh milk and of milk at the receiving stand, a series of investigations were carried on by the department during the year of 1920. Herds in seven different territories in western New York and Pennsylvania were tested during the months of January, March, July, September and October. For the most part the cattle were mixed, with Holstein, Guernsey and Jersey the predominant breeds. In one territory practically all of the cows were Jerseys and in another mostly Holsteins. A total of 766 herds were tested.

The initial work was done on the milk of individual cows, the first titration being run at the farm immediately upon the completion of each milking. Marshall's method (14) was used, the 0.1 N alkali having been carefully prepared and standardized against standard N/5 HCl, previously tested by precipitation with $AgNO_3$ and ignition. The milk was allowed to stand for a few minutes after being drawn to allow the froth to subside, a 9 cc. sample being then withdrawn with a pipette and placed in a white china cup. Titration was made with 3 or 4 drops of

1.25 per cent phenolphthalein, with no added water, with 9 cc. of added water and with 18 cc. of added water. Sufficient tests were run to determine that the addition of water did not affect the titration value expect to make the end point more easily visible. Alkali was added till a faint pink, permanent for one minute, was apparent. The milk from each cow was next strained into a can through filter cloth and a pint sample placed in a sterilized, glass-stoppered bottle. Upon the completion of the whole milking these jars were cooled and taken to the factory, where the development of acidity was followed closely Titrations were made at the end of 16, 20, 24, 40, 44, 47, 50 and 60 hours, souring being induced in one series by elevating the temperature at the end of forty-four hours from 54° to 72°. The effect of pasteurization on the acidity of the milk was tried. In one series this was done at the end of twenty-four hours by raising the temperature to 145° for thirty minutes. The samples were in glass-stoppered jars, giving no outlet for any volatile gas, to which may be due the average increase of 0.005 to 0.01 per cent in the acidity of this series. In another group pasteurization was carried out in open glass jars after forty-eight hours in a similar manner. Here there was a decrease in acidity of as much as 0.055 per cent in one case and an average decrease of 0.015 per cent.

Since measurements of the acidity of milk from individual cows indicated no unusually high values attention was turned to an investigation of mixed herd milk as received at the factory. The method used was to mix the milk in each can, as received, with a dipper and then to take an aliquot sample from each can of the milk brought in from any one herd, the whole being mixed to give a herd composite. These samples were placed in sterilized glass-stoppered jars and determinations made as soon as possible. Ordinarily double titrations were made with 9 cc. of milk and 18 cc. of water with occasional check runs with no added water. In all cases where the milk showed 0.17 per cent or higher acid an investigation was made of any conditions which might have been responsible for it and a check-up was run on the fresh milk from the individual members of the herd at the farm. In order

to ascertain whether high acid corresponded with high solids not fat, as contended by some observers, the current ten-day butterfat test of each herd as regularly run in the factory was recorded and used as a criterion, since high butterfat usually accompanies high solids not fat.

In table 1a are given the results of tests on the individual milk of one group of cows. Temperatures of the samples at time of titration are recorded at the foot of each column. These cows were tested on January 29. Table 1b shows the results obtained from a second group of cows tested on March 26. The dates when the cows freshened are shown in column 2. Temperatures of samples are recorded as above.

Variations in acidity range from 0.10 to 0.175 per cent with an average of 0.136 per cent, ten being below and eight above that figure. The composite of the mixed milks is 0.145 and 0.14 per cent respectively. In six cases, cows 8, 9, 10, 11, 14 and 17, the acidity was lower after sixteen hours than when the milk was freshly drawn, a phenomenon previously observed by Koning. That there is some relation between acidity and the period of lactation is indicated by the fact that the cows that were farthest along, cows 11, 12, 14, 15 and 16, show the lowest acidities. The slow development of acidity when milk is quickly cooled and kept at low temperature is worthy of note. The results obtained are somewhat lower than the majority of those reported by other observers. In only one case, cow 7, would any of these milks have been rejected on a standard of 0.17 or 0.18 per cent and in neither case would the composite milk have been refused, the most important conservation from the standpoint of factory practice or of the producer.

In table 2 are given the results obtained on mixed herd milk in seven territories as received at the factory. Under each 0.005 per cent of acid are listed the number of herds showing that amount, with the average butterfat test of the group immediately below.

In checking up the herds where values higher than 0.165 were in recorded the following results were obtained. The one sample territory A was 0.36 per cent when tested and was curdled four

hours after being received. Of the two samples showing 0.17 in territory C, in both cases improper cooling in conjunction

TABLE 1

(*A*)

COW NUMBER	ACIDITY AT MILKING	AFTER 16 HOURS	AFTER 20 HOURS	AFTER 24 HOURS
	per cent	*per cent*	*per cent*	*per cent*
1	0.14	0.15	0.155	
2	0.10	0.125	0.115	
3	0.12	0.14	0.15	
7	0.11	0.15	0.13	
5	0.13	0.15	0.15	
6	0.115	0.135	0.135	
7	0.17	0.18	0.18	
8	0.13	0.12	0.125	
Composite of above.....	0.145	0.145	0.145	0.145
Temperature of above	70°F.	58°F.	57°F.	58°F.

(*B*)

COW NUMBER	WHEN FRESHENED	ACIDITY AT MILKING	AFTER 16 HOURS	AFTER 20 HOURS	AFTER 24 HOURS	AFTER 40 HOURS	AFTER 44 HOURS	AFTER 47 HOURS	AFTER 50 HOURS	AFTER 60 HOURS	CONDITION OF MILK
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	
9	February	0.17	0.15	0.155	0.16	0.155	0.155	0.155	0.155	0.20	Turning
10	January.....	0.175	0.155	0.16	0.16	0.165	0.16	0.16	0.16	0.165	Sweet
11	September...	0.145	0.14	0.14	0.14	0.145	0.14	0.14	0.14	0.165	Turning
12	September...	0.135	0.135	0.14	0.14	0.14	0.14	0.14	0.14	0.32	Sour
13	January.....	0.155	0.16	0.165	0.165	0.175	0.18	0.175	0.175	0.185	Turning
14	September...	0.11	0.105	0.115	0.115	0.155	0.115	0.115	0.115	0.15	Sweet
15	September...	0.12	0.125	0.125	0.13	0.13	0.13	0.13	0.13	0.14	Sweet
16	December....	0.125	0.14	0.13	0.135	0.135	0.135	0.135	0.135	0.175	Turning
17	January.....	0.145	0.13	0.14	0.14	0.135	0.14	0.145	0.145	0.225	Sour
18	March	0.15	0.16	0.165	0.165	0.165	0.165	0.165	0.16	0.205	Turning
Composite of above.....		0.14	0.14	0.145	0.15	0.15	0.15	0.15	0.16	0.55	Sour
Temperature of above.....		70°F.	52°F.	53°F.	53°F.	54°F.	54°F.	72°F.	74°F.	76°F.	

with hot weather was found to be the cause. Tests made at the farm at milking time showed composits of 0.135 and 0.14 re-

spectively, with no individual cows of high acid. The one sample higher than 0.17 when received was composed of milk from two cans, one of which was rejected as sour after the sample had been mixed. Of the high acid herds in territory D, of which there are two, tests made at the farm showed an acidity on the composite of 0.15 per cent in one case. The other herd consisted of three cows, which gave fresh milk testing 0.15, 0.175 and 0.18 per cent respectively. The farmer was keeping the milk

TABLE 2

FACTORY	0.11	0.12	0.125	0.13	0.135	0.14	0.145	0.15	0.155	0.16	0.17	0.17–0.20
A.....			1	6	13	31	18	17				1
Average butterfat...				3.46	3.65	3.52	3.55	3.72				
B.....	1		2	12	15	15	16	9				
Average butterfat...	5.0		3.92	3.82	4.03	4.16	4.00	4.01				
C.....			5	11	31	41	37	43	28	2	2	1
Average butterfat...			3.5	3.55	3.52	3.51	3.50	3.54	3.57	3.52	3.50	
D.....			1	22	18	25	12	14	2	6	1	1
Average butterfat...			3.5	3.95	3.93	3.89	3.91	3.77	3.60	3.52	4.30	5.0
E.....	5	14		28		39		15		2	1	
Average butterfat...	3.73	3.70		3.85		3.89		3.93		3.70	3.60	
F.....				14		42		20		18	5	
Average butterfat...				3.71		3.74		3.83		3.93	3.82	
G.....	2	14		37		23		19		7		
Average butterfat...	3.98	3.70		3.93		3.93		3.80		4.00		

from the first cow at home for his own use. The mixed milk of the other two cows gave a value of 0.18 per cent. This is an unusual condition. The only herd showing as high as 0.17 in territory E was tested first at the farm for a composite with 0.16 per cent acid apparent. A check-up made the following night on the milk from the individuals of the herd gave results as follows: 0.15, 0.15, 0.12, 0.11, 0.18, 0.16, 0.15, 0.10, 0.13, 0.16 and 0.18 per cent, an average of 0.145 per cent. In con-

nection with these results it may be mentioned that these tests being made in October when the pasture was very short, this farmer was feeding sweet corn to his cows just prior to milking. In territory F tests were made at the farm on the milk from the five herds showing 0.17 per cent acid at the factory. Composites taken at milking time gave 0.14, 0.14, 0.15, 0.16 and 0.17 per cent respectively. Conditions prevented tests on the individual cows of this last herd.

The average acidities in the various territories were: A—0.141, B—0.139, C—0.44, D—0.141, E—0.135, F—0.144, G—0.136. The average acidity of the 766 herds, using the values originally obtained at the factory and including the two cases where the milk was palpably sour, was 0.140 per cent. Examination of the butterfat contents and the deduced solids not fat of the various herds, territories and groups indicate that there is no consistent dependence of high acidity upon high solids-not-fat content. In fact, territory B, where the cattle are practically all Jerseys, was third from the lowest in average acidity and had no values higher than 0.15 per cent. Among the 766 herds examined only two showed conditions, existent in the cows themselves causing an apparent acidity of 0.17 per cent or higher, and one of these might have been eliminated had it been possible to make further tests. Stated differently, only 0.26 of one per cent of all the herds tested, representing 7700 cows, furnished milk which would have been rejected on the basis of an apparently high acid condition, provided the milk was properly and sanitarily handled. Where this was not done such a test proved of value in detecting milk which was improperly cooled or contaminated in some manner.

To summarize the results obtained we may say that the normal acidity of fresh milk of individual cows is from 0.14 to 0.145 per cent, that the normal acidity of composite herd milk as received at the factory is 0.140 per cent and that where milk is handled in a cleanly and careful manner it will not be rejected on the basis of any acid test now in use by the manufacturers of milk products. The value of the acid test in checking the methods of production is, accordingly, clearly demonstrated and

its ease of application combined with this demonstrated reliability warrants its use until such time as some other equally rapid and more dependable method of determining the quality of milk shall have been perfected. Granted that the acid test occasionally detects milks which naturally have an acidity higher than the standard, it must be admitted that such milk is abnormal and comes from abnormal cows. That the quality of this milk may or may not be poorer does not enter into the question. Such milk is abnormal and no practical working scheme can allow for all abnormalities. Milk is occasionally found with butterfat or total solids content below the legal minimum, but who would argue therefrom that the standards maintained by Federal, State and Municipal authorities should be lowered? The percentage of cows and herds showing abnormally high acid is so small as to be negligible and the manufacturer is doing no injustice to the producer when he insists that all milk must be delivered with an acidity below 0.17 or 0.18 per cent, particularly when such a test is applied as an adjunct to the nose and palate of the experienced inspector.

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A MODERN CREAMERY OF THE MIDDLE WEST

J. E. COLONNA

East Pittsburg, Pennsylvania

That modern creameries are tending towards electrification is illustrated in the recent installation made throughout the large model plant of the Peoria Creamery Company of Peoria, Illinois.

The efficiency of electric motor drive hardly needs explanation in this electrical era. The neat, clean appearance of electrified creameries speak for themselves. Every machine has characteristics of its own with respect to continuous or intermittent service which in many cases is quite severe. Accordingly, the right motor is selected for the right kind of work—each machine suited to its exact needs.

The electrical equipment in this creamery, a photograph of which is shown in figure 1, consists in part, of a 100-horse power motor, illustrated in figure 2, for one 125-ton ice machine, and a 40-horse power motor for a 50-ton ice machine. The motors for these two machines operate continuously. Four rotating churns, as shown in figures 3 and 4, are each geared to a 5-horse power motor. Note the suitable splash-protection which has been provided for these motors. Figure 5 shows two pasteurizing machines which are operated by a 5-horse power motor.

Among the various other machines that are electrically operated and which one would expect to find in a modern plant of this kind, the freight elevator has not been excluded; but has also been assured of exceptionally smooth acceleration, by a 30-horse power elevator motor and control.

The advantages of electric drive are of vital interest to the creamery industry on account of the low operating cost, desirable working conditions and the quality and quantity of the resulting output.

FIG. 1. VIEW OF THE PEORIA CREAMERY COMPANY'S PLANT AT PEORIA, ILLINOIS

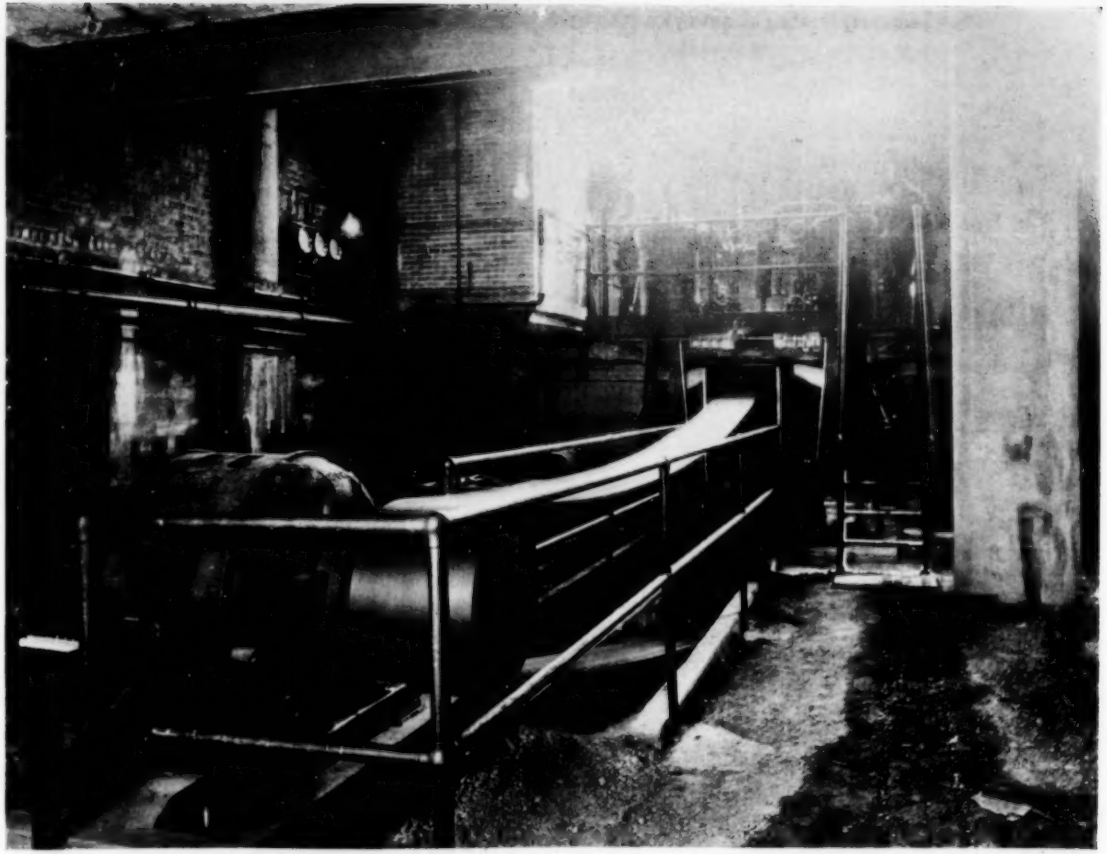

FIG. 2. 100-HORSE POWER MOTOR DRIVING 125-TON ICE MACHINE

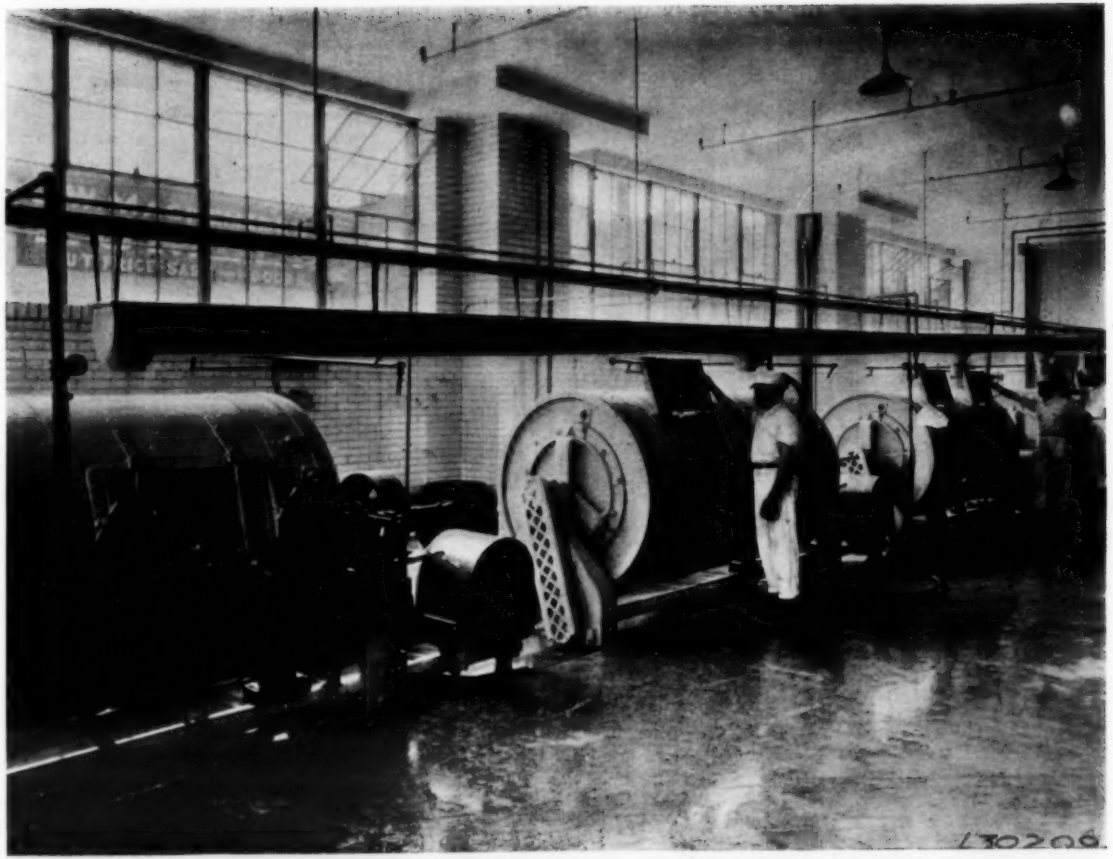

FIG. 3. ROTATING CHURNS EACH DRIVEN BY A 5-HORSE POWER MOTOR

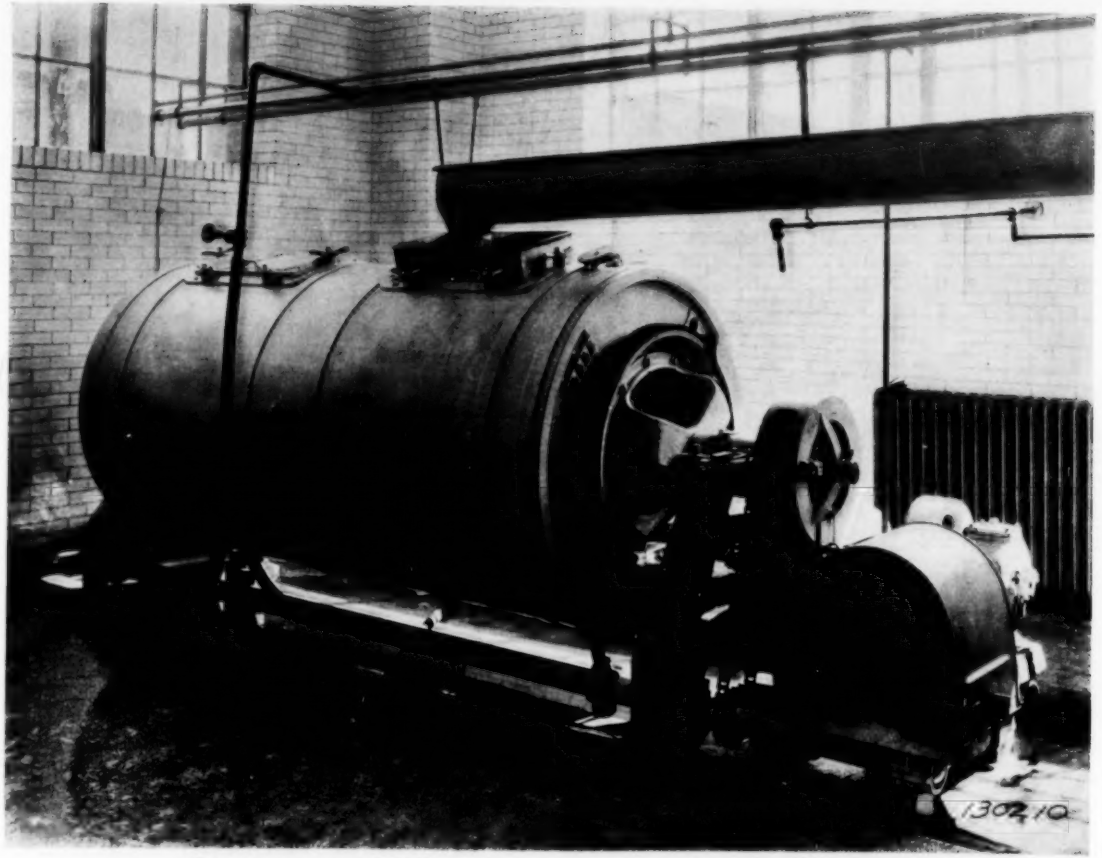

FIG. 4. ROTATING CHURN SHOWING APPLICATION OF INDIVIDUAL MOTOR DRIVE

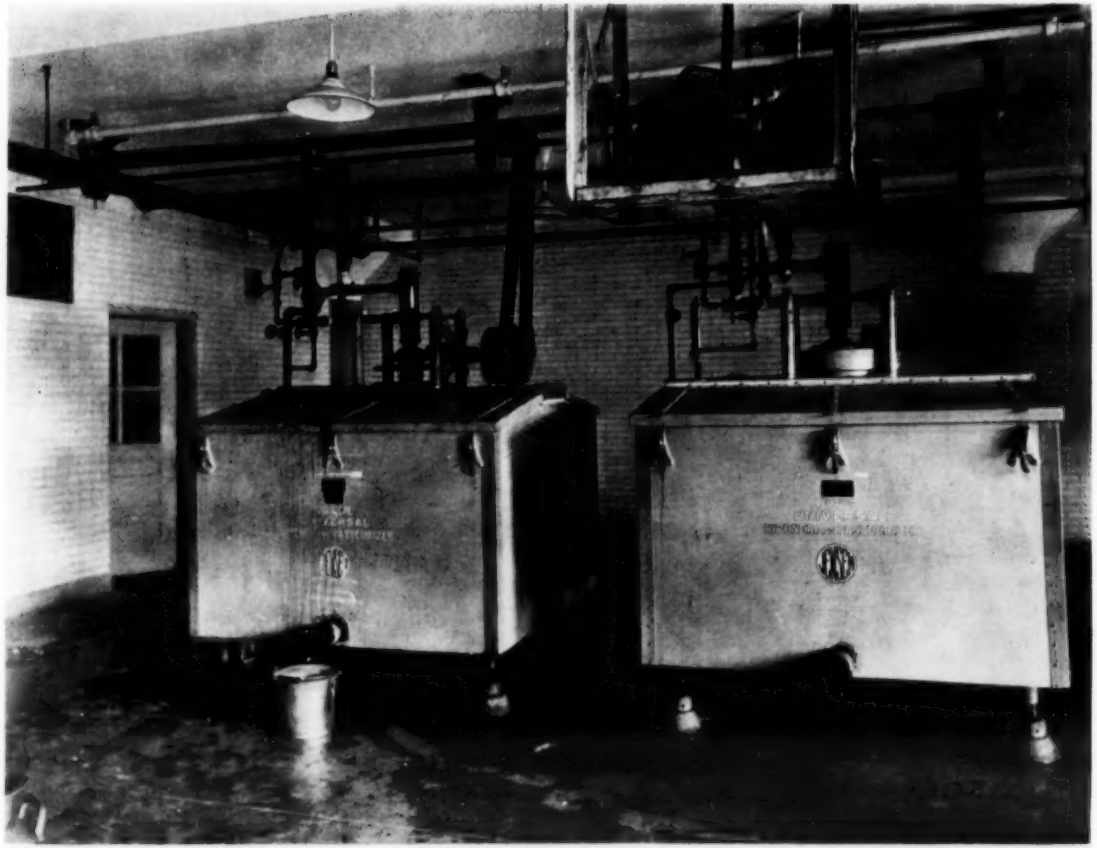

FIG. 5. PASTEURIZING MACHINES BOTH OPERATED BY A 5-HORSE POWER MOTOR

THE PROTEINS OF COTTONSEED MEAL[1]

II. NUTRITIVE VALUE

W. B. NEVENS

Department of Animal Husbandry, University of Illinois, Urbana, Illinois

I. REVIEW OF THE PREVIOUS WORK ON THE NUTRITIVE VALUE OF THE PROTEINS OF COTTONSEED MEAL

Cottonseed meal and flour were found by Richardson and Green (1) to be satisfactory sources of protein for the growth of albino rats when these feeds furnished 18 per cent or more protein to the ration. Mendel (2) states that normal growth has been secured for considerable periods when the globulin of cottonseed was fed in suitable concentration, such concentration having been determined by Osborne and Mendel (3) as 18 per cent of the ration. The latter investigators (4) found that "Cottonseed flour forms a suitable adjuvant for the proteins of corn gluten," producing "satisfactory increments of growth" in chickens. In further studies of the value of certain proteins as supplements to corn gluten, these authors (5) demonstrated that the proteins extracted from cottonseed flour by sodium hydroxide solution were efficient supplements to the proteins of corn gluten for the growth of rats. The use of either the cottonseed globulin or the proteins precipitated from alkali extracts of cottonseed flour in an amount equal to 9 per cent of the ration resulted in "satisfactory growth" and when used to the extent of 6 per cent of the ration "considerable growth" was secured. This is interpreted as attesting the excellent quality of cottonseed proteins. McCollum and Simmonds (6) report the maintenance of body weights by rats fed a ration containing 6 per cent of protein derived from cottonseed.

[1] The results presented in this paper formed part of a thesis submitted to the Graduate School of the University of Illinois in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Husbandry.

In studies of the relation of the quality of proteins to milk production, Hart and Humphrey (7) found an equality in efficiency of the proteins of gluten feed, oil meal, distillers' grains and cottonseed meal as supplements to the proteins of corn meal and alfalfa hay. In later experiments (8) of the same nature, cottonseed meal proteins proved less efficient than the proteins of gluten feed, oil meal and distillers' grains. In these experiments, however, the proteins of the feedingstuff tested formed but 40 per cent or less of the protein content of the ration, and the results were calculated upon the basis of the total nitrogen absorbed by the animals.

The digestibility of the proteins of cottonseed meal is stated by Fraps (9) to be 88.4 per cent in the case of steers and sheep; by Henry and Morrison (10) as 84 per cent, for choice and prime cottonseed meal; by Mendel and Fine (11), who employed dogs as experimental animals, as 67 to 75 per cent compared to 88 to 93 per cent for the proteins of meat; by Rather (12), using men as subjects, as 77.6 per cent in contrast to 96.6 per cent for the proteins of meat; and by Pomaski (13), who employed the gastric juice of the dog, as 99 to 100 per cent.

From a review of the literature, it is apparent that investigations upon the nutritive value of the proteins of cottonseed meal are quite limited in extent. In the majority of experiments cited, the investigators drew their conclusions from the maintenance of live weight, increase in live weight, state of health or combinations of these criteria. In most cases the amount of feed consumed is not recorded, so that it is impossible to judge whether or not the results secured were due to a failure of the animals to consume a sufficient amount of feed to cover their energy requirements. In but one series of experiments (7, 8), were the conclusions based upon metabolism studies. Hence, the further study of the nutritive value of the proteins of cottonseed meal constituted the object of the present investigation.

The toxicity of cottonseed meal

Before proceeding with the investigation, it was considered advisable to determine, so far as possible, whether or not the

toxic principle of cottonseed meal is associated with its proteins, and further, whether cottonseed meal would prove injurious to rats as has been found (14) in the case of many other species of animals.

From an examination of the literature, it would seem that there is but little basis for attributing the toxicity of cottonseed meal to its proteins. The assumption that the high protein content of cottonseed meal is responsible for its harmful effects (15) was denied by Dinwiddie (16), who maintains that this theory is not supported by a study of the recorded feeding tests. Withers and Brewster (17) attributed the toxic principle of cottonseed meal to a certain group of the protein molecule which contains loosely bound sulphur, but later work by Withers and associates (18) led them to conclude that the toxicity is due to the presence of "gossypol," a definite chemical compound soluble in ether and aniline. They believe "gossypol" may be changed to a nearly related substance "D-gossypol," the latter being insoluble in ether but soluble in aniline. When in alcoholic solution either of these compounds forms precipitates with the alcohol soluble proteins of wheat flour and of cottonseed meal. They reason that the reduction of the toxicity of cottonseed meal by heating may be due to the inability of the animal to digest the "gossypol" and "D-gossypol" protein compounds. The theory that gossypol is responsible for "cottonseed meal injury" is strengthened by the work of Alsberg and Schwartz (19).

In their series of feeding experiments with albino rats, Richardson and Green (1) and Osborne and Mendel (5) observed no toxic effects, but the cottonseed kernels themselves proved toxic.

In the light of the foregoing discussion, it seems very doubtful if the toxicity of cotton seed meal may be attributed to either its high protein content or to the character of the proteins which it contains. Further, it seems clear that commercial cottonseed meal of good quality may provide practically the entire nitrogenous components of the ration for albino rats over a considerable period of time with no injurious effects becoming manifest.

II. METHODS EMPLOYED IN STUDYING THE NUTRITIVE VALUE OF THE PROTEINS OF COTTONSEED MEAL

Object of feeding experiment. The object of this phase of the experiment was to study the nutritive value of the proteins of cottonseed meal and to compare their nutritive value with that of the proteins of corn and alfalfa hay for the growth of young albino rats. It was planned to feed rations containing a medium amount of protein, derived from the above mentioned sources, and by means of metabolism studies to determine the extent to which the proteins are utilized for maintenance and growth.

General plan of experiment. Young male albino rats in vigorous, healthy condition and having an initial weight of from 100 to 140 grams were employed. The metabolism periods were each seven days in length, two such periods following each other without intermission with each of the experimental rations tested. Before the first metabolism period and whenever the rations were changed, a three day preliminary or transition period, during which the ration to be employed during the metabolism period was fed, was inserted. It was planned to feed the animals as large amounts of the rations as they would consume, the daily feed allotment being slightly greater than the amount consumed.

The rats were placed in individual glass crystallizing dishes $7\frac{1}{4}$ inches in diameter and $3\frac{3}{4}$ inches in depth, inside measurements. The dishes were provided with weighted wire covers to which were attached large test tubes fitted with rubber stoppers and bent glass tubing, the latter extending downward through the wire cover. The test tubes were kept supplied with ammonia-free water. Large porcelain crucibles for receiving the feed were supported from the covers by means of wire frames. Crystallizing dishes of 60 mm. diameter were employed instead of the crucibles for rations containing alfalfa, which were very bulky. Ventilation was provided by means of a system of rubber tubes which conducted a current of compressed air to the bottom of each dish. From two to three sheets of filter paper, cut to fit the dishes, were placed in the bottom of each dish daily to absorb the urine.

Feces and urine were collected daily. In most cases the filter paper absorbed the urine completely, so that the feces were nearly always found dry. In a very few cases, particularly with rations containing alfalfa which resulted in the production of very bulky feces, there was evidently absorption of urine by the feces, so that it was necessary to extract the feces once or twice with hot acidified water before collecting them. The feces were preserved under 95 per cent alcohol acidified slightly with sulfuric acid. At the end of each seven-day metabolism period, the feces were transferred to large Kjeldahl flasks and digested according to the to the Kjeldahl-Gunning-Arnold method with sulfuric acid, sodium sulfate and mercury. The resulting solutions were transferred to 500 cc. volumetric flasks and aliquots taken for distillation.

After collecting the feces, the urine was extracted from the filter papers by washing with a stream of ammonia-free water acidified with sulfuric acid and held at nearly boiling temperature. The filter paper was thoroughly pulped and pressed out after each extraction by means of a glass rod. From four to six extractions were made, using 40 to 60 cc. of water each time, the sides and bottom of the dish also being thoroughly washed. The extracts were filtered through glass wool into 250 cc. volumetric flasks. The flasks were allowed to remain in the ice box over night. The solutions were then made up to volume at ice box temperature and transferred to 2.5 liter bottles which were kept in a cold storage room at a temperature of 5° to 10° C. until analyzed. About 0.5 gram of powdered thymol was employed as a preservative in each bottle in which the week's urine was collected. The composites were thoroughly mixed and aliquots measured out in the cold for total nitrogen determinations.

The feed was weighed daily into the crucibles and mixed with a little nitrogen-free water to the consistency of a thick paste. The following day the feed residues were scraped out and dried in the same oven and at the same temperature as the rations used. In some cases the animals scattered the feed from the crucibles about the metabolism dish. In such cases the eed

remaining in the metabolism dish at the time of collecting the excreta was carefully separated and added to the feed residues. When thoroughly dry the weight of the feed residues was determined and the amount of feed actually consumed during the seven-day period calculated. By previous tests in this laboratory it was found that the error involved in this calculation due to a difference in the moisture content of the residues and ration was less than 1 per cent, and further that the nitrogen contents of the residues and ration were identical (20).

Preparation of rations. In preparing the experimental rations, the starch used was first dextrinized by heating on the steam bath after the addition of cold water and a few crystals of citric acid. When ground corn formed one of the constituents of a ration, it was mixed with the starch and the starch of the mixture dextrinized. The other ingredients were then added, the agar being dissolved in boiling water and added at the boiling temperature. When necessary more hot water was added and the ingredients thoroughly mixed. The rations were dried on glass plates, placed above the steam bath, finely ground and dried in an oven at a temperature of about 40°C. After drying for several days, the rations were mixed, sampled for analysis and placed in tightly covered glass jars.

The nitrogen free ration consisted of the following:

	per cent
Salts	5
Butterfat	10
Sucrose	8
Starch	74
Agar	3

Water soluble vitamin, 150 mgm. of solids per 100 grams of ration.

The composition of the other rations is shown in table 1. The salt mixture used was compounded according to the formula of Osborne and Mendel (21), while the water soluble vitamin consisted of Osborne and Wakeman's (22) fraction II of the concentrated extract of the water soluble vitamin of brewers' yeast. The stock supply of the latter was prepared in the form of a water solution which was preserved by means of a small quantity of chloroform and kept in the ice box. The butter-

fat was obtained by placing fresh creamery butter in large beakers, heating to a temperature of 50° to 60° on the steam bath, centrifuging for an hour or until the fat became water clear, and then siphoning off the clear fat.

It was planned that all rations containing a protein feedingstuff should carry 10 per cent of protein (N × 6.25), but the actual content of protein was slightly higher, ranging from 10.38 per cent to 11.28 per cent, due to the fact that some of the constituents used in making up the ration had a slightly higher moisture content than the dried rations.

TABLE 1

Composition of experimental rations (expressed in percentage)

CONSTITUENT	RATION						
	1*	2	3	4*	5	6	7
Cottonseed meal	23.9			13.1		10.3	7.7
Corn		72.7		32.3	28.4		19.3
Alfalfa hay			63.5		40.6	35.7	29.3
Starch	55.1	6.3	18.5	33.7	13.0	36.0	25.7
Agar	3.0	3.0		3.0			
Sucrose	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Butterfat	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Salts	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total nitrogen content	1.750	1.660	1.806	1.777	1.708	1.790	1.782

* Water soluble vitamin preparation added at the rate of 1.5 mgm. of solids per gram of ration to rations 1 and 4.

In preparing the rations in which two or more feedingstuffs were combined an effort was made to have each feedingstuff furnish an equal amount of digestible protein, using the coefficients of digestibility secured in period 2 as a basis for calculation, but keeping the total content of crude protein the same throughout the experiment, namely, 10 per cent.

The cottonseed meal used in the rations was a part of the same sample which was employed in the analytical study presented in a preceding paper. Through the courtesy of the Plant Breeding Division of the Agronomy Department of this university a

quantity of "high protein" corn containing 2.2 per cent nitrogen was secured, which made it possible to formulate a suitable corn ration containing 10 per cent protein. All of the feedingstuffs used were in a finely ground condition before compounding the rations.

Accuracy of metabolism work with small animals. Since the accuracy of metabolism work depends in large measure upon the accuracy of the collection of the excreta, especially when such small amounts of nitrogen are involved as in the case of the smaller laboratory animals, several experiments were carried out to test the accuracy of the methods employed.

Each day during period 6, when 6 rats were receiving the same feed mixture, the paper residues remaining after extraction of the urine were collected in glass jars and placed in the ice box. At the end of the metabolism period, the entire mass of residues, including the glass wool used in filtration, was transferred to a 2 liter beaker and boiled for some time with about 1 liter of water acidified with sulphuric acid. The extracts were decanted and the procedure repeated, the acidified water being pressed out from the residues. The extracts were filtered through glass wool, evaporated on the steam bath and transferred to Kjeldahl flasks for total nitrogen determination. The paper residues also, together with the glass wool, were transferred to large Kjeldahl flasks, and total nitrogen determined. The results of these determinations are shown in table 2. The nitrogen extracted in the procedure described just above is assumed to be of urinary origin and is compared to the total amount of urinary nitrogen excreted during the week. It is shown that, as an average of 6 such determinations, the error in the collection of urine amounted to 2.0 per cent of the total nitrogen.

The nitrogen remaining in the paper residues which was not extracted by boiling with acidified water was assumed to be fecal nitrogen. In collecting the feces it was sometimes impossible to entirely remove the fecal matter from the filter papers, especially when the rations tended to cause a laxative condition. Such a condition was not a constant effect with any ration employed, but was more frequent with rations containing alfalfa.

With the latter rations, three filter papers were generally placed in each dish daily, while with the other rations two papers were used. Analysis of the filter paper showed that seven filter papers of the size used contained 1.06 mgm. of nitrogen. In making the calculations shown in table 2 it was assumed that the nitrogen originally contained in the filter papers was insoluble in the hot dilute acid employed in extraction and this has been deducted from the non-extractable nitrogen remaining in the paper residues. To the extent that such nitrogen is soluble in

TABLE 2

Test of the completeness of extraction of nitrogen from filter papers used as absorbents during one metabolism period

RAT NUMBER	EXTRACTABLE N IN PAPER PULP	N IN URINE COLLECTED	TOTAL URINARY N EXCRETED	ERROR IN COLLECTION OF URINE	NON-EXTRACTABLE N IN PAPER PULP	N IN FECES COLLECTED	TOTAL FECAL N EXCRETED	ERROR IN COLLECTION OF FECES	TOTAL N IN PAPER PULP RESIDUES	TOTAL N OF EXCRETA FOR PERIOD	TOTAL ERROR IN COLLECTION
	mgm.	*mgm.*	*mgm.*	*per cent*	*mgm.*	*mgm.*	*mgm.*	*per cent*	*mgm.*	*mgm.*	*per cent*
2	12.5	558.4	570.9	2.2	25.5	546.8	572.3	4.5	1143.2	38.0	3.3
3	15.9	716.3	732.2	2.2	25.8	833.7	859.5	3.0	1591.7	41.7	2.6
5	9.0	619.3	628.3	1.4	22.2	645.3	667.5	3.3	1295.8	29.2	2.3
6	13.2	541.0	554.2	2.4	20.1	615.8	635.9	3.2	1190.1	33.3	2.8
8	11.5	652.5	664.0	1.7	12.9	672.0	684.9	1.9	1348.9	24.4	1.8
9	18.3	764.3	782.6	2.3	28.0	602.0	630.0	4.4	1412.6	46.3	3.3
Average.....	13.4		655.4	2.0	22.4		675.0	3.3	1330.4	35.5	2.7

* After deduction of nitrogen contained in same number of clean filter papers.

hot dilute acid, however, it would tend to offset to a small degree the losses in the collection of urine, although the correction would not be in proportion to the variable total urinary nitrogen. The error in the collection of feces was found to be 3.3 per cent, using the average of six determinations, or, comparing the total nitrogen lost to the total nitrogen excreted in urine and feces during the week, the total error in the collection of both feces and urine is 2.7 per cent.

The results obtained in this test were applied to the metabolism data for period 6, the period during which this test was conducted,

to determine what effect the incomplete collection of the excreta has upon the utilization coefficients. It is evident that an error in the collection of the excreta is reflected directly in the nitrogen balance and in the percentage utilization. Using the average values given in table 2 of 13.4 mgm. of nitrogen representing uncollected urine and 22.4 mgm. of nitrogen representing uncollected urine and 22.4 mgm. of nitrogen representing uncollected feces during a seven day period, and applying them to the data for the individual animals during period 6 it is found that the percentages of utilization of absorbed nitrogen as given in the tables are approximately 2 per cent too high, while the percentages of absorbed nitrogen retained are slightly more than 3 per cent too high. Like results are obtained for period 7 during which the animals received the same ration as in period 6.

The completeness of the collection of urine was tested in still another way, that of the recovery of urea which was added in the form of a standard solution to the daily feed. Two mature rats were employed in the test. After the excretion of urinary nitrogen had been reduced to a nearly constant level by subsistence on protein free rations for seven days, known amounts of urea were added to the ration.

The excretion of this extra nitrogen was very prompt, as indicated by the results of the test as shown in table 3. In the case of rat 10, the results are somewhat difficult to interpret, owing to the fact that the consumption of feed decreased rapidly, evidently resulting in catabolism of small amounts of body protein to furnish energy for the body. By using the figures for the average excretion of nitrogen during the three days preliminary to the first urea day as the level of the endogenous nitrogen during the three urea days, the apparent recovery of the urea nitrogen amounted to 119 per cent. Similar results are obtained if the average nitrogen excretion during the preliminary and subsequent periods are employed. If it be assumed that, owing to a decrease in feed consumption below that of the energy requirements, the endogenous nitrogen should be taken as corresponding to that in the subsequent period, then the recovery of the urea nitrogen was approximately 100 per cent. Undue

emphasis should not be placed upon the results given by this animal, however.

With rat 11 more reliable data were obtained as it was not evident that the feed consumption was deficient in meeting the energy requirements. By using the average nitrogen excretion during both preliminary and subsequent periods as the level of the amount of body nitrogen excreted, the recovery of

TABLE 3

Test of the completeness of collection of urine by addition of urea to the ration

DAY	LIVE WEIGHT	FEED EATEN	UREA N ADDED	DAILY URINARY N
		Rat 10		
	grams	grams	mgm.	mgm.
1	182	10.5	0	35.6
2		10.5	0	24.0
3		10.5	0	23.5
4	178	6.1	42.1	74.6
5		6.1	42.1	83.0
6		6.1	42.1	76.0
7		4.6	0	35.9
8	167	5.6	0	35.8
		Rat 11		
1	176	7.2	0	42.8
2		7.2	0	30.2
3		7.2	0	39.8
4		7.7	56.5	82.8
5		7.7	56.5	101.8
6		5.4	0	37.5
7	164	5.4	0	29.3

urea nitrogen amounted to 95 per cent of that fed. If the average of the amounts of nitrogen excreted during days 3 and 6 be used as this level, then the recovery of urea nitrogen was practically 100 per cent.

It is evident from the data presented concerning the recovery of urea nitrogen that the method for the collection of urine as employed in these experiments, gives very nearly quantitative results.

Further tests of the metabolism method employed, which were performed in this laboratory and are described below, show that loss of ammonia due to bacterial decomposition of the urine does not occur to any appreciable extent.

In the first test, three portions of urine of 5 cc. each were measured out for total nitrogen determination. At the same time 5 cc. portions of urine were added to each of six metabolism dishes containing the usual number of filter papers. Three of these dishes were allowed to stand at room temperature in the metabolism laboratory, while the remaining three were placed in an oven at a temperature of about 40°C. At the end of twenty-four hours, the urine was collected from all six dishes in the same manner as employed in the metabolism work, i.e., by washing with hot acidified water. As a result of this test it was found that 5 cc. of urine contained 28.18 mgm. of nitrogen, while the amounts of nitrogen recovered from the dishes kept for twenty-four hours at room temperature and at 40°C. were, respectively, 27.61 mgm. and 27.54 mgm.

In the second of these tests, the urine from one rat receiving a constant amount of the same ration was collected daily. On the first, third, and fifth days the urine was collected at once by washing with acidified water in the usual manner. The urine was made up to a volume of 250 cc. and aliquots taken at once for total nitrogen determinations.

On the alternate days the urine was not collected at the end of the twenty-four hour period, but the filter paper was moistened and the dish allowed to stand another twenty-four hours in the metabolism laboratory before extraction in the usual maner. The rat meanwhile was transferred to a clean dish. At the end of the second day the urine was collected by washing as usual, made up to volume, and aliquots taken for total nitrogen determination. The results of the test are shown in table 4. It is evident that there was no appreciable loss of nitrogen due to bacterial decomposition even after the metabolism dishes had stood for two days.

How shall the nutritive value of proteins be compared? In attempting to compare the biological values of various feeding-

stuffs, it is first necessary to select a suitable basis for comparison. Several different methods for comparison are in use. As pointed out in the introduction one of the most common methods is to base conclusions upon the character of the growth secured, the principal index in such a case being the gain in live weight. Some of the data from table 1 of the appendix are brought together in table 5. These data were all obtained in periods 2 and 3. The rats consuming the cottonseed meal ration showed marked fluctuations in gain in live weight which can not be accounted for on the basis of a variable food intake. With the corn ration, there was a gain in weight by one rat in one period

TABLE 4

Effect of allowing metabolism dishes to stand twenty-four hours and forty-eight hours before the collection of urine

DAY OF EXPERIMENT	DAILY URINARY N WHEN COLLECTED AT END OF TWENTY-FOUR HOURS	DAILY URINARY N WHEN COLLECTED AT END OF FORTY-EIGHT HOURS
	mgm.	mgm.
1	57.9	
2		64.9
3	60.8	
4		67.3
5	63.2	
6		60.3
Average	60.3	62.1

only. The nitrogen of the ration, however, was being used by the body to a considerable extent, for on a nitrogen-free ration the same animals lost 16 to 19 grams in weight during a period of equal length, compared to 1 to 2 grams on the corn ration. Likewise, there was also a large variation in gains in weight by the rats receiving the alfalfa ration, the average gains of rats 7 and 8 being almost zero. It is probable that many factors other than the quality and amount of the protein consumed influence the gain in weight, such as the proportion of carbohydrates in the ration, amount of water drank, exercise, the proportions of gain which is protein or fat, etc. While interpretations based upon the gain in live weight may lead to reliable

conclusions in some instances, the adoption of such a criterion in the present case would certainly be a fallacious procedure.

It is a matter of common knowledge that all animals require protein food for keeping the body tissues intact, known as the maintenance requirement, and secondly, that growing animals need an additional quantity of protein for the construction of new tissue. If a standard for the comparison of the value of the proteins of feedingstuffs for growth is based simply upon the proportion of the nitrogen of the feedingstuff which is retained by the body, the values secured in such a manner are subject to gross errors. With such a method of computation the apparent value of the proteins for growth depends largely upon the nitrogen intake, or, in other words, upon the amount of feed eaten, and this in turn is subject to individual idiosyncracy and the palatability of the ration. As mentioned elsewhere, when the ration proves unsatisfactory, rats tend to eat less and less from day to day. By reference to table 5 it may be seen that both rats 5 and 6 ate less of the corn ration during period 3 than during period 2. Rat 5, during period 2, retained 16 per cent of the nitrogen absorbed, but during period 3, when the amount of feed consumed was evidently too little to maintain the animal's live weight, the nitrogen of the excreta was greater than the nitrogen intake, so that there was a loss of nitrogen from the body resulting in a negative value for the percentage of absorbed nitrogen retained. Similarly, the percentage of absorbed nitrogen retained by rat 6 falls from 23 per cent in period 2 to 9 per cent in period 3, a change which in this instance may also be attributed to a decreased food intake. Were the average percentage of the absorbed nitrogen retained by rats 5 and 6 taken as a measure of the utilization of the proteins of corn for growth, it would be a distorted picture of the facts.

There seem to be factors other than the amount of feed consumed which render the use of the percentage of absorbed nitrogen retained an unsatisfactory criterion of the utilization value of the proteins of feedingstuffs. As may be seen by reference to table 5, the percentage of nitrogen retained by rat 7 in periods 2 and 3 falls from 23 per cent to 8 per cent, and in the case of

rat 8 the percentage falls from 16 per cent in period 2 to 6 per cent in period 3. These violent fluctuations are not due entirely to a decreased nitrogen intake, for in the case of rat 7 the feed intake increased slightly during the second period. They are, however, associated with a slightly decreased digestibility, although there may be other causative factors.

TABLE 5

A comparison of three methods of expressing the utilization of proteins

RAT NUMBER	PERIOD	RATION	FEED CONSUMED DAILY	GAIN IN WEIGHT FOR PERIOD	UTILIZATION OF ABSORBED N FOR MAINTENANCE AND GROWTH*	ABSORBED N RETAINED*
			gm.	*gm.*	*per cent*	*per cent*
1	2	Cottonseed meal	9.52	11	63	31
1	3	Cottonseed meal	9.48	6	65	29
2	2	Cottonseed meal	8.66	9	64	21
2	3	Cottonseed meal	8.57	5	64	17
3	2	Cottonseed meal	11.51	12	71	44
3	3	Cottonseed meal	12.47	11	70	43
4	2	Corn	7.44	2	49	15
4	3	Corn	8.05	0	47	15
5	2	Corn	7.66	0	54	16
5	3	Corn	6.30	−1	43	
6	2	Corn	7.49	−1	55	23
6	3	Corn	6.35	−2	48	9
7	2	Alfalfa hay	9.33	6	62	23
7	3	Alfalfa hay	9.50	−5	57	8
8	2	Alfalfa hay	9.19	2	58	16
8	3	Alfalfa hay	8.20	−2	57	6
9	2	Alfalfa hay	11.42	3	67	22
9	3	Alfalfa hay	13.67	7	73	38

* For method of calculation of these percentages, see table 1 of the appendix.

Any suitable criterion used in feeding experiments for the comparison of the utilization of proteins for growing animals must necessarily consider the effect of the proteins in providing nitrogen for maintenance, for in growing animals these processes proceed concurrently. It is doubtful if the true protein requirement for the maintenance of a growing animal can be determined by feeding a ration containing protein, for Waters (23) has shown

that when young steers received a ration which just maintained their live weight some of the growth processes continued. Similar results were obtained by Aron (24).

Perhaps the nearest approach to the determination of the exact amount of nitrogen required for the maintenance of a growing animal is a study of the nitrogen excretion when the ration consists entirely of carbohydrates and this is being taken in an amount in excess of the body's energy requirement. Under such conditions the nitrogen excretion falls to a very low level, often to one third or less of that during starvation, as shown by Folin (25), Landergren (26), Cathcart (27) and Thomas (28). The amount of protein then being catabolized has been defined by Rubner (29) as the "wear and tear" quota of protein metabolism, which requires a "repair quota" of protein in the diet in order to replace it. A "growth quota" must be supplied the young animal in addition to the "repair quota" in order that growth may take place. Using dogs as experimental animals, Michaud (30) found, when protein in the form of casein or dog tissue was fed in amounts equivalent to the protein minimum after the metabolism had been reduced to this level, that there was no further loss of nitrogen from the body. Thomas (28) found, after the reduction of the nitrogen excretion by a carbohydrate diet to the minimum level, that nitrogen equilibrium could be restored by the ingestion of an amount of protein nitrogen in the diet equal to the amount of nitrogen being eliminated in the excreta.

On a nitrogen-free diet the amount of nitrogen excreted daily in the feces was about 1 gram, and this amount was not increased with a nitrogen intake of 3 grams furnished by a highly digestible protein. With diets producing a large bulk of feces he found that a greater proportion of digestive juices was eliminated, increasing the nitrogen content of the feces.

In the interpretation of the feeding experiments which follow it is assumed that the amount of protein required for body maintenance is a constant value for each individual at a given weight. Such an assumption is entirely in harmony with the theories of many investigators in the fields of both human and animal nu-

trition. Folin (25), as a result of his study of the different forms in which nitrogen is excreted on high and low protein diets, was led to formulate his theory of two distinct types of metabolism. The endogenous is most characteristically represented by the excretion of creatinine, which, "on a meat-free diet is a constant quantity, different for different individuals, but wholly independent of quantitative changes in the total amount of nitrogen eliminated." Folin's results have been substantiated by an immense amount of investigation concerning urinary creatinine, and his theory of protein metabolism is now almost universally accepted in its main essentials, although it has been necessary to modify this view slightly with our increased knowledge of the chemistry of the proteins.

The constancy of the protein minimum for the individual is accepted by Lusk, Thomas and others. That this minimum differs between individuals and is subject to slight variation due to environmental, temperamental and dietary changes, possibilities which are not precluded by Folin's theory, is brought out by Cathcart (31):

> As regards the uniformity of the protein minimum it may be definitely stated that there is no single minimum—common to all men and to all conditions. Rubner, Caspari and others also hold firmly to this opinion. Caspari quotes the work of Larguier des Bancels in 1903 in confirmation of this belief in the existence of mutiple protein minima. The facts that can be cited against a common minimum are many in number. Thus the caloric value of the diet given influences very materially the amount of nitrogenous material required, as is shown, for example, in the experiments of Voit and Korkunoff. Then, as Rubner has pointed out, the temperature influences quite markedly the course of protein metabolism. Finally, another factor of considerable importance may be mentioned, the activity of the organism.

In the sphere of animal nutrition, the constancy of the maintenance requirement for farm animals is recognized by Kellner, Armsby and Haecker. C. Voit and Kellner also proved conclusively that work production of varying intensity by farm animals does not increase the protein metabolism appreciably.

In this connection it should be stated that some of the current theories of protein metabolism are not in complete harmony with that just mentioned. Among these are the reversible reaction theory of Sherman (32), which seeks to account for the functions which the food protein serves in body maintenance by the assumption that the absorption of the amino acids liberated in digestion causes an increased concentration of these in the tissues which checks or even reverses the hydrolysis of tissue protein. This theory is hardly compatible with the known facts regarding the constancy of the endogenous metabolism, which has been found (33) to be uniform from hour to hour, as evidenced by the creatinine elimination, even during digestion and absorption of proteins. Absorption of the protein digestion products from the alimentary tract presumably occupies only a portion of the twenty-four hour period, so that even if the endogenous catabolism were inhibited by the increased concentration of amino acids, it would be only temporary, for it has been shown (34) that, in adult rats, protein feeding has only a very slight effect upon the amino acid concentration in the tissues. This known slight increase in the amino acid content of the tissues during digestion would not be of sufficient magnitude to inhibit the action of digestive enzymes when a digestion experiment is conducted in vitro. Further, it is unreasonable to assume that anabolism and catabolism of tissue proteins are simply reversible phases of the same reaction and that both these processes are promoted by the same enzyme. In the young growing animal protein feeding has been demonstrated (34) to increase considerably the amino acid content in the tissues. Were the endogenous metabolism inhibited entirely during the time this concentration is maintained, as must be assumed from the reversible reaction theory, then the catabolism of tissue protein per unit of weight in the young growing animal would be but a fraction of that of a mature animal.

Osborne and Mendel (35) explain the maintenance protein requirement upon the need of certain amino acids to serve special physiological functions, such as the formation of the active principles of the internal secretions and hormones. This theory

assumes, therefore, that when the animal is receiving a nitrogen-free ration, body tissue must be catabolized to furnish the essential amino acids, but that, on the other hand, when a ration containing a complete assortment of amino acids in sufficient amount is being consumed the endogenous metabolism is only a fraction of that on a non-nitrogenous ration, and that then only the catabolism of the internal secretions or the tissues which regulate metabolism would be affected. Under these conditions the muscles would scarcely be affected and the creatinine elimination would bear little relation to the endogenous metabolism. Moreover, the theory does not satisfactorily account for the effect of ammonium salts, mixtures of amino acids and single amino acids in partially supplying nitrogen for maintenance.

Since the plan of procedure and method of calculation employed in this investigation are dependent primarily upon the basic assumption that the endogenous metabolism of the animal organism is constant in character and amount for an individual at a given age and weight, an examination of the data obtained during all the metabolism periods was made in order to ascertain, if possible, whether this assumption is substantiated by the experimental results at hand. In making this examination, the data embodied in appendix table 1 were employed to obtain the first set of values shown in the column headed "As determined" under each "period" of table 6. These values were obtained by deducting the sum of the endogenous nitrogen and the metabolic nitrogen in the feces from the daily urinary nitrogen and calculating the percentage of the daily nitrogen intake which the remainder forms. The second column of values under each "period," headed "As calculated," was obtained in the same way as those in the first column, except that the average value for daily urinary nitrogen as determined with nine rats in period 1, i.e., 22 mgm. per 100 grams live weight, is used in calculating the "endogenous nitrogen" for periods 2 to 7, inclusive, instead of the individual values determined in the same period.

It is shown in table 6 that the individual daily urinary nitrogen values for rats 2, 5, and 9 are above the average, while those for

rats 3, 6 and 8 are below the average. Hence, for comparison, rats 2 and 3, 5 and 6, and 8 and 9 are arranged in pairs. The rats of each pair received the same rations throughout the experiment. It is natural to assume that two animals of the same age and weight and in a comparable nutritive condition will utilize the same ration with an equal degree of efficiency, subject of course to inherent individual variability. By reference to table 6, it may be noted that this holds true to a very great extent, although the natural variations to be expected in biological work of this kind are in evidence.

TABLE 6

The proportion of the daily intake of nitrogen above maintenance which appears in the urine (expressed in percentage)

RAT NUMBER	PERIOD 2		PERIOD 3		PERIOD 4		PERIOD 5		PERIOD 6		PERIOD 7	
	As determined	As calculated	As determined	As calculated	As determined	As calculated	As determined	As calculated	As determined	As calculated	As determined	As calculated
2	12.0	16.3	9.8	13.1	1.7	5.3	8.3	12.4	8.9	13.4	8.8	13.7
3	8.8	8.3	9.4	8.9	7.8	7.2	7.3	6.9	9.9	9.3	9.9	9.2
5	26.5	29.1	35.0	38.2	18.7	21.0	18.5	21.1	12.3	14.4	11.4	13.7
6	23.9	20.0	31.3	26.7	21.0	17.5	16.4	12.3	12.6	9.5	14.0	11.1
8	9.1	7.4	7.8	5.8	15.6	14.3	10.4	8.9	14.3	12.5	9.7	7.7
9	4.1	5.5	1.9	3.1	15.8	17.3	14.9	16.4	16.0	17.6	16.4	18.1

Considering first the values listed under the headings "As determined" in each period it is evident that there is a marked uniformity exhibited by the animals of each pair throughout the different experimental periods with but few exceptions. For example, it is shown that rats 2 and 3 eliminate in the urine about the same proportion of the nitrogen intake above maintenance "as determined," with the exception of periods 2 and 4. Rats 5 and 6 show quite uniform results throughout the entire six periods. Rats 8 and 9 do not very widely from each other in periods 4, 5 and 6. Moreover, certain rations seem to have a pronounced effect on these percentages. Rats 5 and 6 received the corn ration during periods 2 and 3, and the corn-

cottonseed meal ration during periods 4 and 5. With both of these rations, the proportion of the daily nitrogen intake eliminated in the urine was greater than with the other rations, but both animals behaved alike in this respect.

On the other hand, when the average values for the endogenous nitrogen of the urine are used in calculating maintenance, the variations in the percentages of the nitrogen intake above maintenance appearing in the urine of the animals of each pair are greatly exaggerated in 14 of the 18 cases involved, as shown under the headings "As calculated." In one of the four cases, that of rats 5 and 6, period 7, there is no change. In the other three cases, those of rats 2 and 3, period 4, and rats 8 and 9, periods 2 and 3, the spread is lessened slightly. In many cases the use of an average maintenance factor increases the spread between the animals of a pair as much as 200 per cent. These data seem to indicate quite conclusively that the endogenous metabolism is a function of the individual animal and that this is a definite and probably constant value under a given set of conditions. This is quite in harmony with the theory of Folin (25) respecting the constancy of endogenous metabolism. In calculating the results of these experiments, therefore, the use of individual maintenance values is evidently justifiable.

If, having determined the minimal "wear and tear" quota of an animal by appropriate metabolism experiments, feeding tests are then initiated to study the utilization of the proteins of feedingstuffs by that animal, it is possible to calculate the proportion of the nitrogen excreted in the urine which is of endogenous origin and likewise the amount of fecal nitrogen whose source is metabolic. This method follows closely that of Thomas (28) in calculating the biological values of foodstuffs. Such a criterion evaluates the proportion of the nitrogen of the food which is actually utilized by the animal in its metabolism, whether the animal is consuming an amount of protein which is not quite sufficient for it to maintain its live weight, or whether growth is permitted. The values obtained by applying this method of calculation to the data of metabolism periods 2 and 3 are shown in the last column of table 5. An inspection of these values

shows that this method overcomes some of the objections raised to the other methods. When the gain in live weight falls to zero or a little below, but at the same time it is evident that some of the nitrogen of the ration is being used by the animal, the percentage "utilization of the absorbed nitrogen for maintenance and growth" is lowered, but is, nevertheless, a very distinct positive value. With a slight decrease in food intake, there is usually a corresponding fall in the "utilization of absorbed nitrogen for maintenance and growth" coefficient, but this decrease is not so extreme as when the results are calculated upon the basis of the "absorbed nitrogen retained." Moreover, a decrease in the feed intake to just below the maintenance level does not result in a negative value. On the whole the "utilization of absorbed nitrogen for maintenance and growth" coefficients are much less variable than those of the "absorbed nitrogen retained." The former method is subject to a coefficient of variability of 8.4 per cent when all of the values obtained in the six metabolism periods are considered, and a mean is assumed for each ration. Similarly, the same values when calculated upon the basis of the percentage of "absorbed nitrogen retained" have a coefficient of variability of 27.7 per cent, a striking and important difference.

In this investigation, therefore, the endogenous metabolism of the experimental animals was studied during a metabolism period in which a nitrogen-free ration was fed, and this was followed by six metabolism periods in which the proteins of cottonseed meal were compared with those of corn and alfalfa hay.

III. DISCUSSION OF THE RESULTS

Metabolism of the rat on a nitrogen-free ration. During the first eleven days of the experiment the rats which had been consuming an ordinary stock ration were given nitrogen-free rations prepared as described above. On the fifth day collection of the feces and urine was begun, and continued for seven days. In order to check the results secured during the first period of the experiment, three of the rats were again placed on nitrogen-free

rations during period 6, after having received nitrogenous rations during the intervening time. The principal data of these trials are included in table 7. The rats lost slightly more than 2 grams of weight per head daily. For the first few days of the period the animals ate the ration in large quantities, but as they apparently found the feed unsatisfactory, they consumed smaller and smaller

TABLE 7

Metabolism of the rat when receiving a nitrogen free ration

RAT NUMBER	PERIOD	INITIAL WEIGHT	FINAL WEIGHT	AVERAGE FEED CONSUMED DAILY	DAILY URINARY NITROGEN	DAILY FECAL NITROGEN	DAILY URINARY N PER 100 GRAMS LIVE WEIGHT	FECAL NITROGEN PER 100 GRAMS FEED
		grams	*grams*	*grams*	*mgm.*	*mgm.*	*mgm.*	*mgm.*
1	1	99	88	6.51	25	17	27	253
2	1	118	102	7.43	31	19	28	255
3	1	134	116	9.07	26	24	21	259
4	1	135	118	8.79	24	22	19	251
5	1	120	104	7.29	28	20	25	273
6	1	129	110	7.86	21	21	18	270
7	1	123	107	7.43	23	20	20	266
8	1	122	109	8.14	22	24	19	298
9	1	126	114	7.43	29	18	25	246
Average				7.78			22	264
1	6	113	102	6.10	22	19	20	306
4	6	135	130	9.02	16	20	15	223
7	6	118	105	4.76	24	17	21	357
Average				6.63			19	295

amounts from day to day, and a few of the animals scattered the feed from the containers at once upon being fed.

It was found that, while subject to some individual variation, the amount of urinary nitrogen per 100 grams of live weight is fairly constant, the average value of 22.4 mgm. obtained agreeing almost exactly with that found by Mitchell (20) in a large number of metabolism periods. From the results secured in period 6 it appears that there is a slightly less intense endogenous metabolism as the animal becomes older, as evidenced by a decreased

excretion of urinary nitrogen per 100 grams live weight. The slight increase in the case of rat 7 during period 6 as compared with period 1 is evidently due to a deficient food consumption during the former period, necessitating the catabolism of body protein to furnish energy. The individual values obtained in period 1 for urinary nitrogen per 100 grams live weight are used in the subsequent tables for calculating the utilization of the various rations, the values always being corrected to the average live weight of the particular animal during that period.

The quantity of fecal nitrogen per 100 grams feed when the rat is consuming a nitrogen-free ration is quite a constant factor, although this relationship seems to be affected somewhat by extremes in the amount of feed consumed, as may be noted in the case of rats 4 and 7, period 6. Perhaps a more potent factor in causing this fluctuation is the varying amount of filter paper eaten, as found by Mitchell (20) in an experiment in this laboratory in which rats during one period had no access to filter paper and during the other actually consumed some paper.

It is recognized that the calculation of the metabolic nitrogen in the feces by the method described is subject to an error when applied to a variety of rations. Were the content of crude fiber in all rations the same as in the synthetic nitrogen-free ration, the assumption that the metabolic nitrogen of the feces varies directly with the amount of feed consumed would be valid, but with rations varying as widely in the percentage of crude fiber as the corn and alfalfa rations, the adoption of such an assumption evidently leads to an error of undetermined magnitude. However, the method of correcting the absorbed nitrogen and the nitrogen balance, by the use of the factor for metabolic fecal nitrogen obtained on nitrogen-free rations, undoubtedly gives values nearer the truth than if no such corrections were made, since the actual metabolic fecal nitrogen on the experimental rations containing protein was very probably greater per 100 grams of food consumed than the factors used. In computing the amount of metabolic fecal nitrogen shown in the tables that follow, the values for fecal nitrogen per 100 grams feed eaten in

period 1 in the case of each animal are applied to the data for the same animals in later periods.[2]

If it is true, as seems probable from the meager data obtained, that the endogenous metabolism of the rat becomes less intense per unit of live weight as the animal approaches maturity, then in conducting investigations of the kind under consideration it would, no doubt, be advisable to introduce a metabolism period using a nitrogen free ration every six or eight weeks. With these data available it would be possible to make linear corrections for any changes in the requirement of the basal metabolism. In the tables showing the utilization of the proteins which follow, such corrections have not been attempted with the limited number of data at hand, but should the data secured with rats 1 and 4 be used for such a purpose, it would necessitate changes in the utilization coefficients given of not more than 1 to 2 per cent as a maximum.

Palatability of rations. The results obtained in the six metabolism periods during which nitrogenous rations were fed are summarized in table 8.

From an inspection of the figures giving the amounts of feed consumed daily it is evident that all rations containing cottonseed meal were readily consumed by the animals, attesting to the palatability of this feed, even when forming as much as 24 per cent of the ration. When corn was the sole source of protein in the ration the amounts of feed consumed were smaller than with any other ration. Ground corn seems to be less palatable to rats than whole corn for the latter is usually eaten readily. Perhaps another reason why less of the corn ration was consumed than the alfalfa ration, for example, is that the corn ration was much more digestible and had a higher calorific value, so that less of it was required to supply the energy requirements. The ration in which cottonseed meal and corn were combined was consumed in greater quantities than the corn ration but not so freely as the cottonseed meal ration. Alfalfa hay proved very palatable, as all rations of which it formed a part were readily eaten.

[2] These values, as well as those for urinary nitrogen, when being used for these calculations, were extended to one more decimal place than shown in table 7.

TABLE 8

The utilization of the proteins of cottonseed meal, corn and alfalfa hay; summary of results

RAT NUMBER	PERIODS	RATION	AVERAGE LIVE WEIGHT	FEED CONSUMED DAILY	ABSORBED NITROGEN	ABSORBED NITROGEN RETAINED	ENDOGENOUS NITROGEN	UTILIZATION OF ABSORBED NITROGEN	N ABSORBED RETAINED
			grams	*grams*	*mgm.*	*mgm.*	*mgm.*	*per cent*	*per cent*
1	2 + 3	Cottonseed meal	98	9.50	124.8	54.5	25.3	64	30
2	2 + 3		109	8.62	107.1	38.2	30.4	64	19
3	2 + 3		127	11.99	169.6	91.3	28.0	71	44
Average			111	10.04	133.8	61.3	27.9	66	31
1	4 + 5	Cottonseed meal +	114	10.83	125.9	52.9	30.6	67	26
2	4 + 5	alfalfa hay	126	11.06	131.7	58.1	35.7	71	29
3	4 + 5		159	15.68	185.0	89.5	33.7	67	34
Average			133	12.52	147.5	66.8	33.3	68	29
2	6 + 7	Cottonseed meal +	136	9.82	124.3	45.6	38.2	63	21
3	6 + 7	alfalfa hay + corn	186	14.01	173.0	72.5	39.4	65	27
Average			161	11.92	148.7	59.0	38.8	64	24
4	2 + 3	Corn	118	7.75	118.9	34.6	22.8	48	15
5	2 + 3		108	6.98	105.9	24.7	27.1	49	8
5	2 + 3		115	6.92	104.5	34.1	20.3	52	16
Average			114	7.22	109.8	31.1	23.4	49	13
4	4 + 5	Cottonseed meal +	129	9.81	141.4	59.5	24.9	60	30
5	4 + 5	corn	118	8.30	127.8	43.6	29.2	59	21
6	4 + 5		124	8.11	120.2	48.9	22.3	60	28
Average			124	8.74	129.8	50.7	25.5	60	26
5	6 + 7	Cottonseed meal +	139	10.90	136.9	49.3	34.9	62	18
6	6 + 7	alfalfa hay + corn	141	11.20	146.8	64.8	25.1	61	28
Average			140	11.05	141.9	57.1	30.0	61	23
7	2 + 3	Alfalfa hay	104	9.42	99.4	37.2	21.4	60	16
8	2 + 3		103	8.69	92.9	33.7	20.0	58	11
9	2 + 3		121	12.55	128.1	61.2	29.4	70	30
Average			109	10.22	106.8	44.0	23.6	62	19
7	4 + 5	Alfalfa hay + corn	115	12.64	149.1	56.8	23.3	54	20
8	4 + 5		118	14.08	175.8	78.9	23.3	59	28
9	4 + 5		134	12.51	166.6	70.6	32.7	62	29
Average			122	13.08	163.8	68.8	26.4	58	26
8	6 + 7	Alfalfa hay + corn	142	11.81	152.6	65.0	27.0	61	26
9	6 + 7	+ cottonseed meal	154	13.06	184.0	76.1	38.0	62	29
Average			148	12.83	168.3	70.6	33.0	61	27

Utilization of proteins. In the summary of results shown in table 8 two methods of calculating the utilization of the proteins fed are included for comparison, although, for reasons discussed above, the second method, namely, the utilization of the absorbed nitrogen for both maintenance and growth, is employed in the discussion here.

The utilization of the nitrogen absorbed from a cottonseed meal ration containing 10 per cent of crude protein was found to be 66 per cent, using the average results of six metabolism periods with three rats. The utilization of the proteins of alfalfa hay was found to be only slightly less than that of cottonseed meal, namely, 62 per cent.

When these two feeds were combined in such proportion that each furnished about an equal amount of digestible protein to the ration, very interesting results were secured, indicating a slight supplementary effect of the proteins from these two sources. This effect was not pronounced, the utilization percentage being 2 per cent above that of cottonseed meal alone and 6 per cent above that of alfalfa hay alone. It is noted that during the periods when the cottonseed meal alfalfa hay ration was fed, greater quantities of feed were consumed and larger amounts of nitrogen were absorbed than with either the cottonseed or alfalfa hay rations alone, which may in some unknown way have operated in effecting a more efficient utilization of the nitrogen, although the same conditions hold true in the case of both groups of rats which received either the corn or the alfalfa ration during two periods and were then changed to rations containing proteins from both sources.

It was found that the proteins of corn were utilized the least efficiently of those of the three feedingstuffs compared. When corn was combined with cottonseed meal or with alfalfa hay the resulting utilization coefficients tended toward a mean of the utilization coefficients secured with these feedingstuffs when fed alone, but were nearer that of the feed other than corn. For example, the utilization coefficients found for the corn and cottonseed meal rations were 49 per cent and 66 per cent respectively, the mean of these two being 57.5 per cent, but

the utilization coefficient found for the cottonseed meal-corn ration was 60 per cent. Possibly this represents a slight supplementary relationship.

The results obtained with the ration in which cottonseed meal, corn and alfalfa hay were combined were remarkably uniform. Of the twelve values obtained with rats receiving this ration during two metabolism periods each, the lowest value was 57 per cent and the highest 67 per cent, the average of all being 63 per cent. The combination of the proteins from three different sources failed to indicate any farther supplementary effect of the proteins.

The high nutritive value of the proteins of cottonseed meal manifested by these experiments is in substantial accord with the conclusions of Richardson and Green (1), Osborne and Mendel (3, 4, 5, 6) and McCollum and Simmonds (6). They do not seem to be in harmony with the findings of Hart and Humphrey (8) who studied the utilization of the proteins of cottonseed meal for milk production, but since growth and milk production are dissimilar functions an absolute comparison of the results of the two experiments is not valid.

Correlation of chemical composition with nutritive value. In seeking for an explanation of the differences in the nutritive value of the proteins of these feedingstuffs based upon differences in their chemical makeup, it is evident first of all that their nutritive values do not vary so widely as the analytical data at hand would indicate. For example, the differences found between the utilization of the proteins of cottonseed meal and alfalfa hay was but 4 per cent,while from an examination of the data in table 5 of a preceding paper, it is apparent that cottonseed meal contains more than twice as much arginine nitrogen and nearly twice as much histidine nitrogen as alfalfa hay, while the latter contains more than three times as much nonprotein nitrogen as the former.

Several theories may be advanced in explanation of this apparent inconsistency. In the first place, alfalfa hay is shown to have a lower digestibility than either cottonseed meal or corn. There is no evidence to preclude the possibility that the char-

acter of the nitrogen absorbed from alfalfa hay differs qualitatively from that remaining in the undigested residues. Judging from the ease with which tyrosine is split off from proteins in tryptic digestion in vitro, it is possible that the absorbed nitrogen contains a greater proportion of amino acids essential to the body than the unabsorbed portion. Further, the sterochemical arrangement of the amino acids in the protein molecule may affect the extent to which the digestive enzymes are able to cause hydrolysis of the different proteins. A second consideration is the possible interchangeability of the various forms of nitrogen in nutrition, as already pointed out in the case of arginine and histidine. To what extent the nonprotein nitrogen of alfalfa hay is utilized in maintenance is problematical, but since there is no reason to doubt that the degradation products of crude protein are able to serve in this capacity, it is possible that a large part of the absorbed nonprotein nitrogen fulfills some of the requirements of the animal body.

It is reasonable to assign the higher content of the basic amino acids of cottonseed meal as the reason for its superiority over the proteins of alfalfa and corn. In the case of the last mentioned feedingstuff, there is the additional factor of a comparatively low lysine content to be considered, although from the studies of Osborne and Mendel concerning the lysine requirements for growth, a lysine content of 2.2 per cent of the protein appears to be ample for normal growth.

In the absence of further information respecting the character of the mono-amino acid and nonprotein nitrogen content of these feedingstuffs, a detailed picture of which the Van Slyke analysis does not include, correlations between the chemical composition and nutritive value of the proteins of feedingstuffs can proceed little beyond the realm of the functions and relationships of the basic amino acids.

Comparison of feed consumption with that of farm animals. It was noted during the course of this investigation that the rats consumed an enormous amount of feed in proportion to their live weights. In some few cases the amount of air dry feed eaten daily was equivalent to as much as 10 or 11 per cent of the

TABLE 9

Comparison of feed consumption by albino rats with that of farm animals

SPECIES OR BREED AND CLASS OF ANIMAL	LENGTH OF FEEDING PERIOD	FEEDS IN RATION	NUMBER OF ANIMALS FED	AVERAGE AGE	AVERAGE LIVE WEIGHT	FEED EATEN DAILY PER 100 POUNDS LIVE WEIGHT
	days			*days*	*pounds*	*pounds*
Percheron fillies*	28	Corn + oats + alfalfa hay	10	227	854	2.2
	28	Corn + oats + alfalfa hay	10	683	1484	1.8
Hereford steers†	35	Corn + linseed meal + clover hay	4		978	2.5
	28	Corn + linseed meal + clover hay	4		1466	1.5
Jersey heifers‡	30	Corn + bran + linseed oil meal + alfalfa hay	4	365	472	2.9
	90	Corn + bran + linseed oil meal + alfalfa hay	4	730	839	1.8
Holstein heifers‡	30	Corn + bran + linseed oil meal + alfalfa hay	4	365	656	2.4
	90	Corn + bran + linseed oil meal + alfalfa hay	4	730	1112	1.8
Swine§			174		38	6.0
			495		128	3.8
			105		320	2.4
Sheep**					45	2.1
					127	1.1
Albino rats	42	Cottonseed meal + corn + alfalfa hay + synthetic mixture	9		129††	8.4§§
	21 or more***	18 per cent protein	17		175 200††	4.6§§

* From Bul. 192, Ill. Agr. Exp. Sta.

† From Bul. 197, Ill. Agr. Exp. Sta. Data concerning "Full-feed lot."

‡ From Nebr. Agr. Exp. Sta. Unpublished manuscript. Data concerning "Heavy fed groups."

§ From Henry and Morrison, Feeds and Feeding, 15th ed. p. 569.

** Calculated from data of Weiske as quoted by Armsby, The Nutrition of Farm Animals, p. 432.

†† Grams.

§§ Grams per 100 grams live weight.

*** From Osborne and Mendel. Protein Minima for Maintenance. Jour. Biol. Chem., 1915, xxii, 241.

live weight. It seemed of interest to compare the feed consumption of albino rats with that of farm animals. Such a comparison is made in table 9. The tabulations of horses and cattle include in each case two entries of the same group of animals at different ages and weights. It is known that the horses and cattle were restricted in the amount of concentrates consumed but were offered roughage to practically the limit of their appetites. Hence a comparison of the feed consumption of these animals with that of the first group of rats, which were the ones concerned in this investigation, is warranted, but the data are indicative only. Data for the amount of feed consumed by the swine, sheep and second group of rats is not at hand.

It is evident from the data presented that the rat is a voracious eater, even when receiving rations comparable to those of farm animals. A rough approximation places the relative amounts of feed eaten by rats as about three times that of various breeds and classes of farm animals, if swine be excepted. The fact is also brought out, as has previously been noted by others, that the young animal consumes much more feed in proportion to live weight than when older and heavier.

Cottonseed meal probably not toxic to albino rats. None of the rations containing cottonseed meal seemed to exert any harmful influence upon the rats consuming it. Three of the animals received continuously for 7 weeks rations containing from 7.7 per cent to 23.9 per cent cottonseed meal with no evidence of toxic symptoms but remained in excellent nutritive condition. This observation is in agreement with those of Richardson and Green (1) and Osborne and Mendel (5).

SUMMARY OF THE DISCUSSION OF THE NUTRITIVE VALUE OF THE PROTEINS

Evidence is presented to show that metabolism experiments with the rat as a subject can be carried out with a high degree of accuracy.

Different methods of expressing the nutritive value of the proteins of feedingstuffs are discussed. The plan of employing the

results secured in a preliminary and final metabolism period during which the animal receives a nitrogen free ration, for the calculation of the percentage of the absorbed nitrogen utilized, is favored. In comparing the nutritive value of the combined proteins of the feedingstuffs cottonseed meal, alfalfa hay and corn, it was found that when one of these feeds furnished the sole source of protein in rations containing 10 per cent of crude protein, the utilization of the proteins for the growth of albino rats was, in the order in which the feedingstuffs are named, 66 per cent, 62 per cent and 49 per cent, respectively.

When rations containing these feedingstuffs, combined in various ways, but with each feed furnishing an equal amount of digestible protein, were fed, there was evident no clear cut supplementary effect of the proteins of one feed upon another, except in the case of the combination cottonseed meal and alfalfa hay, which showed a slight effect.

No symptoms of toxicity were noted as a result of feeding rations containing cottonseed meal over a period of seven weeks.

When suitable rations are provided, the albino rat consumes an enormous amount of feed in proportion to its live weight.

The writer desires to express his appreciation of the assistance of Dr. H. H. Mitchell in outlining the method used in this investigation and for many helpful suggestions. He is also indebted to Dr. H. S. Grindley for his encouragement and general supervision of the thesis problem.

APPENDIX TABLE 1

The utilization of the proteins of cottonseed meal, corn and alfalfa hay

RAT NUMBER	PERIOD	RATION	INITIAL WEIGHT	FINAL WEIGHT	DAILY FEED CONSUMED	(a) DAILY INTAKE OF N	(b) DAILY URINARY N	(c) DAILY FECAL N	(d) METABOLIC N IN FECES	(e) ENDOGENOUS N	(f) ABSORBED N RETAINED	(g) UTILIZATION OF ABSORBED N‡	(h) ABSORBED N RETAINED	(i) DIGESTIBILITY: Ordinary coefficient	(j) DIGESTIBILITY: Corrected coefficient
			grams	*grams*	*grams*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*per cent*	*per cent*	*per cent*	*per cent*
1	2	Cottonseed meal	92	103	9.52	166.7	71.8	62.2	24.1	24.4	56.8	63	31	63	77
2	2		104	113	8.66	151.6	70.7	62.2	22.1	30.4	40.8	64	21	59	74
3	2		121	133	11.51	201.4	74.3	68.3	29.7	26.8	88.5	71	44	66	71
Average												66	32	63	74
1	3	Cottonseed meal	103	109	9.48	165.8	68.8	68.9	24.0	26.1	52.1	65	29	58	73
2	3		113	118	8.57	149.9	67.0	69.2	21.9	30.4	35.6	64	17	54	69
3	3		133	144	12.47	218.1	82.2	74.1	32.3	29.2	94.1	70	43	66	81
Average												66	30	59	74
1	4	Cottonseed meal +	109	113	10.60	189.8	68.6	100.1	26.9	29.7	48.0	67	24	47	62
2	4	alfalfa hay	118	129	11.39	203.9	67.2	96.1	29.1	34.6	69.7	76	38	53	67
3	4		145	160	14.91	267.0	91.6	132.4	38.7	32.2	81.7	66	32	50	65
Average												70	31	50	65
1	5	Cottonseed meal +	113	121	11.06	198.0	77.40	90.9	28.0	31.4	57.7	66	28	54	68
2	5	alfalfa hay	129	133	10.73	192.1	80.00	93.0	27.4	36.7	46.5	66	19	52	66
3	5		160	173	16.45	294.5	99.30	140.6	42.7	35.1	97.3	67	35	53	67
Average												66	27	53	67

1	6	N-free.	113	102	6.10		21.5	18.7							
2	6	Cottonseed meal +	134	137	10.13	180.5	79.8	78.1	25.8	37.9	48.4	67	22	57	71
3	6	alfalfa hay + corn	182	188	14.47	257.9	102.2	119.1	37.5	39.0	74.1	64	26	54	69
												66	24	56	70
Average								73.3†			42.7	67		57	71
2	7	Cottonseed meal +	137	138	9.51	169.4	77.7	(65.5)*	24.3	38.5	(50.5)	(69)	19	(61)	(76)
3	7	alfalfa hay + corn	188	189	13.54	241.3	98.8	106.8	35.1	39.8	70.8	65	27	56	70
Average												62	23	57	71
4	2	Corn	117	119	7.44	123.4	80.3	28.5	18.6	22.7	33.2	49	15	77	92
5	2		108	108	7.66	127.2	81.7	30.1	20.9	27.1	36.3	54	16	76	93
6	2		116	115	7.49	124.3	70.4	32.4	20.2	20.4	41.7	55	23	74	90
Average												53	18	76	92
4	3	Corn	119	119	8.05	133.6	88.3	29.5	20.2	22.8	36.0	47	15	78	93
5	3		108	107	6.30	104.6	80.8	28.0	17.2	27.0	13.0	43	–	73	90
6	3		115	113	6.35	105.3	70.4	25.6	17.2	20.2	26.5	48	9	76	92
Average												46	12	76	92
4	4	Corn and cottonseed	122	131	9.95	176.8	80.4	61.1	24.9	24.3	60.2	60	31	66	80
5	4	meal	110	115	8.56	152.0	80.0	52.4	23.3	28.2	42.9	58	20	66	81
6	4		116	128	8.48	150.8	76.2	49.6	22.9	21.6	47.9	56	25	67	82
Average												58	25	66	81
4	5	Corn and cottonseed	131	135	9.67	171.9	83.5	53.9	24.2	25.5	58.7	59	29	69	83
5	5	meal	115	125	8.04	142.8	78.5	42.0	21.9	30.1	44.2	61	22	71	86
6	5		128	132	7.73	137.4	66.4	42.0	20.9	23.0	49.9	63	30	69	85
Average												61	27	70	85

APPENDIX TABLE 1—*Continued*

RAT NUMBER	PERIOD	RATION	INITIAL WEIGHT	FINAL WEIGHT	DAILY FEED CONSUMED	(a) DAILY INTAKE OF N	(b) DAILY URINARY N	(c) DAILY FECAL N	(d) METABOLIC N IN FECES	(e) ENDOGENOUS N	(f) ABSORBED N RETAINED	(g) UTILIZATION OF ABSORBED N‡	(h) ABSORBED N RETAINED	(i) DIGESTIBILITY: Ordinary coefficient	(j) DIGESTIBILITY: Corrected coefficient
			grams	*grams*	*grams*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*per cent*	*per cent*	*per cent*	*per cent*
4	6	N-free.	135	130	9.02		16.3	20.1							
5	6	Cottonseed meal +	134	139	11.03	196.6	88.5	92.2	30.1	34.3	46.1	60	15	53	68
6	6	corn + alfalfa	133	143	10.68	190.3	77.3	88.0	28.9	24.4	53.9	60	24	54	69
Average												60	20	54	69
5	7	Cottonseed meal +	139	144	10.77	191.9	86.8	82.1	29.4	35.5	52.4	63	21	57	73
6	7	corn + alfalfa	143	148	11.72	208.9	86.8	78.2	31.7	25.8	75.6	62	33	63	78
Average												63	27	60	76
7	2	Alfalfa hay	103	109	9.33	171.0	61.0	91.4	24.8	21.3	43.4	62	23	47	61
8	2		103	105	9.19	165.8	62.5	91.1	27.4	20.0	39.6	58	16	45	62
9	2		116	119	11.42	206.3	65.4	122.5	28.1	28.8	46.5	67	22	41	54
Average												62	20	44	59
7	3	Alfalfa hay	109	104	9.50	171.5	63.4	102.4	25.2	21.4	30.9	57	8	40	55
8	3		105	103	8.20	148.0	55.9	88.7	24.4	20.0	27.8	57	6	40	57
9	3		119	126	13.67	246.9	68.4	136.3	33.7	30.0	75.9	73	38	45	58
Average												62	17	42	57

7	4	Alfalfa hay + corn	107	117	12.86	219.6	95.1	105.3	34.2	22.5	53.4	51	17	52	68
8	4		106	125	14.82	253.1	105.8	111.9	44.2	22.2	79.6	55	25	56	73
9	4		127	132	12.18	208.0	94.5	79.6	30.0	31.7	63.9	60	26	62	76
Average												55	23	57	72
7	5	Alfalfa hay + corn	117	122	12.41	211.9	89.4	95.3	33.0	24.0	60.2	57	23	55	71
8	5		125	129	13.34	227.8	88.0	101.5	39.8	24.4	78.1	62	30	55	73
9	5		132	140	12.84	219.3	97.5	76.1	31.6	33.3	77.3	63	32	65	80
Average												61	28	58	75
7	6	N-free.	118	105	4.76		23.8	17.0							
8	6	Cottonseed meal +	134	141	12.06	214.9	93.2	96.0	36.0	26.4	61.7	57	22	55	72
9	6	corn + alfalfa	147	1 57	13.55	241.5	109.2	86.0	33.3	37.2	79.6	62	30	64	78
Average												60	26	60	75
8	7	Cottonseed meal +	141	147	11.55	205.8	82.0	90.1	34.4	27.6	68.3	64	29	56	73
9	7	corn + alfalfa	157	160	12.57	224.0	106.6	75.8	31.0	38.8	72.6	62	28	66	80
Average												63	29	61	78

Method of calculation:

1. $a - b - (c - d) = f$
2. $\frac{e + f}{a - (c - d)} \times 100 = g$
3. $\frac{a - c - b}{a - c} \times 100 = h$
4. $\frac{a - c}{a} \times 100 = i$
5. $\frac{a - (c - d)}{a} \times 100 = j$

* A loss occurred during Kjeldahl digestion of feces.

† Based on amount of fecal nitrogen per gram of feed in Period 6.

‡ As calculated for both maintenance and growth.

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DAIRY NOTES

J. W. HENDRICKSON

University of Nebraska, Lincoln, Nebraska

The following appointments and resignations are reported by the Dairy Division, United States Department of Agriculture:

Appointments

P. N. Peter, a graduate of Maryland State College, who has taken post-graduate work at Yale University, has been appointed for chemical research work in connection with dairy by-products. Mr. Peter was formerly employed in research work at the Picatinny Arsenal, Dover, N. J.

M. H. Fohrman, a graduate of the University of Missouri with a master's degree also from that institution, has been appointed to assist in the cattle breeding experiments conducted by the Dairy Division. Mr. Fohrman came from the University of Minnesota where he was employed as assistant professor of dairy husbandry and supt. of official testing.

W. E. Wintermeyer, a graduate of Pennsylvania State College, who for several years has been engaged in extension work, has been appointed to assist in the organization of bull associations.

Earle O. Whittier, a graduate of the University of Maine, with a master's degree from that institution, has been appointed for chemical research work on the utilization of dairy by-products. Mr. Whittier served as instructor in chemistry at Simmons College, and as research chemist with the E. I. du Pont De Nemours Company before coming to the Dairy Division.

Robert E. Hardell, a graduate of the University of Wisconsin, who specialized in dairy manufacturing, has been appointed for experimental cheese investigations in the Dairy Division.

Stanley Evans, a graduate of Ohio State University, who specialized in dairying, has been appointed for experimental cheese work at the Grove City (Pa.) laboratory of the Dairy Division.

L. S. Edwards, has been reappointed for creamery extension work in Mississippi and Louisiana.

Resignations

C. L. McArthur, who has been engaged in bacteriological investigations in the Dairy Division since 1918, has resigned to accept a position with the F. X. Baumert Cheese Co., Antwerp, New York.

H. F. Zoller, who has been engaged in chemical research work in the Dairy Division for the past four years, has resigned to accept a position with the Parke-Davis Co., Detroit, Mich.

Miss Louise G. Holbrook, who has been engaged in extension work in the greater utilization of milk, under the direction of Miss Jessie M. Hoover, has resigned, effective July 20, 1921.

E. H. Parfitt, who has been employed on cheese investigations for the past 15 months, has resigned to accept a position in dairy manufacturing at Purdue University.

Dr. H. A. Ruehe, head of the Department of Dairy Husbandry of Illinois has just returned to his duties after a year leave of absence in which he was pursuing work for his doctorate degree at Cornell.

Dr. W. B. Nevens, who was formerly in charge of dairy production work at the University of Nebraska has completed his graduate work and has also accepted the position of Assistant Professor of Dairy Nutrition at the University of Illinois.

Professor H. P. Davis formerly of the Dairy Department of Idaho University and of the Dairy Division at Washington, D. C., has accepted the position of Chairman of the Dairy Department at the University of Nebraska.

A recent number of the JOURNAL has a list of instructors in most of the institutions in the United States.

The following list of instructors was reported for Illinois on August 12, 1921:

Dairy Department Staff, Urbana, Illinois

H. A. Ruehe, Ph.D., Professor Dairy Manufacturing, Head of Department

M. J. Prucha, Ph.D., Professor Dairy Bacteriology

W. J. Fraser, M.S., Professor Dairy Farming

W. L. Gaines, Ph.D., Professor Milk Production

W. W. Yapp, M.S., Assistant Professor Dairy Cattle
O. R. Overman, Ph.D., Assistant Professor Dairy Chemistry
A. S. Ambrose, B.S., Associate Dairy Manufacture
C. S. Rhode, B.S., Assistant Professor Dairy Husbandry Extension
H. A. Ross, B.S., Associate Dairy Economics
Mason H. Campbell, M.S., Associate Dairy Husbandry
R. W. Peterson, B.S., Associate Dairy Husbandry
B. A. Stiritz, B.S. Associate Dairy Manufacture
P. H. Tracy, B.S., Assistant Dairy Manufacture
W. B. Nevens, Ph.D., Assistant Professor Dairy Nutrition
F. P. Sanmann, B.S., Assistant Dairy Chemistry
H. F. Hall, B.S., Assistant Dairy Economics
F. A. Davidson, B.S., Assistant Dairy Husbandry
J. M. Brannon, Ph.D., Associate Dairy Bacteriology

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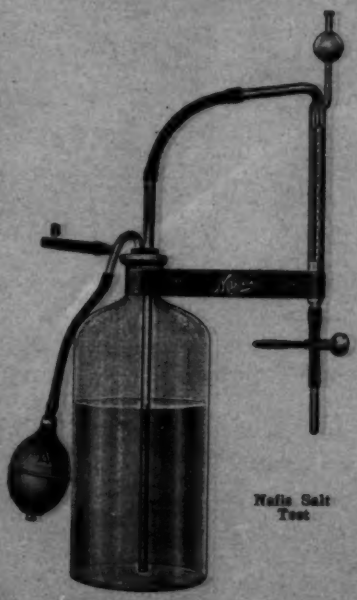

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